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Yoshida et al.

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[45] **Date of Patent: Dec. 26, 2000**

[54] **ROTARY ATOMIZING HEAD TYPE COATING DEVICE**

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[58] **Field of Search** ..... 239/104, 106, 239/124, 223, 224, 320, 322, 323, 329, 290, 700, 703, 708, 600, DIG. 14, 583; 222/148, 325, 326, 327, 386, 389; 901/43

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,555,058	11/1985	Weinstein et al.	239/223
4,813,603	3/1989	Takeuchi et al.	239/223 X
5,221,050	6/1993	Jeffries et al.	239/323 X
5,310,120	5/1994	Ehinger et al.	222/389 X
5,704,977	1/1998	Baumann et al.	239/708 X
5,727,735	3/1998	Baumann et al.	239/124 X
5,788,164	8/1998	Tomita et al.	239/223 X

FOREIGN PATENT DOCUMENTS

6-134354	5/1994	Japan .
7-323245	9/1996	Japan .
8-229442	9/1996	Japan .
8-229446	9/1996	Japan .

Primary Examiner—Andres Kashnikow
Assistant Examiner—Steven J. Ganey
Attorney, Agent, or Firm—Oblon, Spivak, McClelland, Maier & Neustadt, P.C.

[57] **ABSTRACT**

By provision of paint cartridges of different colors which are detachably mounted on a coating system, the paint can be changed from one color to another in a multi-color coating operation without necessitating to discharge residues of a previous color. The paint cartridge of each color is replaceably mounted on a housing. Each cartridge is provided with a paint valve **(46)** which functions to communicate and shut off a paint supply passage in a feed tube. In addition, a thinner valve which serves to communicate and shut off a thinner passage on the housing is provided either on the side of the housing or on the side of the cartridge. These arrangements make it possible to cope with multiple color changes on one coating system. Since both of the paint valve and thinner valve are opened and closed by spray-on and spray-off command signals, respectively, the paint spray can be turned on and off immediately in response to these command signals.

15 Claims, 13 Drawing Sheets

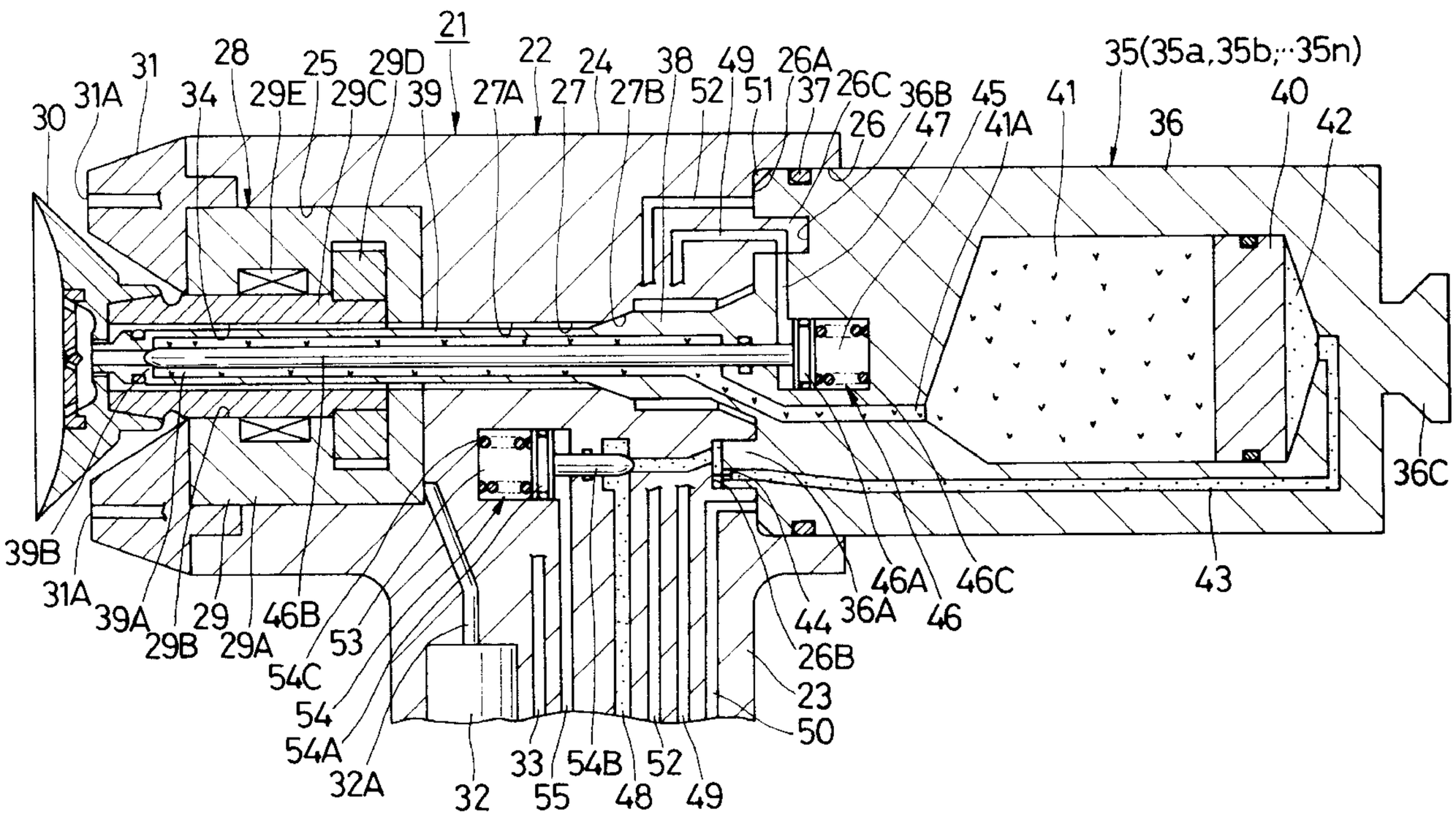
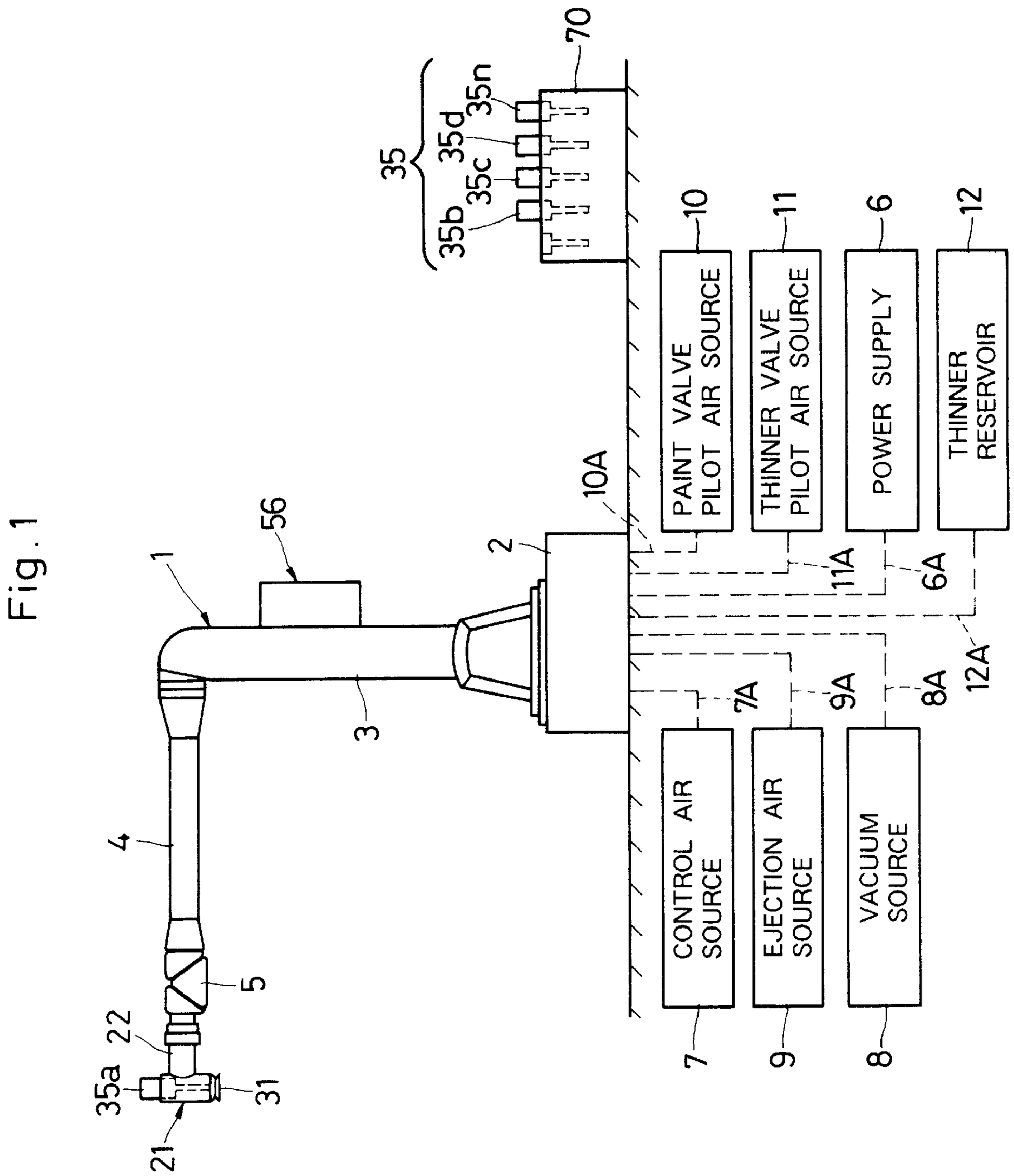


Fig. 1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35d
35n
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PAINT VALVE PILOT AIR SOURCE
11
THINNER VALVE PILOT AIR SOURCE
6
POWER SUPPLY
12
THINNER RESERVOIR
56
1
2
3
4
5
22
35a
31
21
11A
6A
12A
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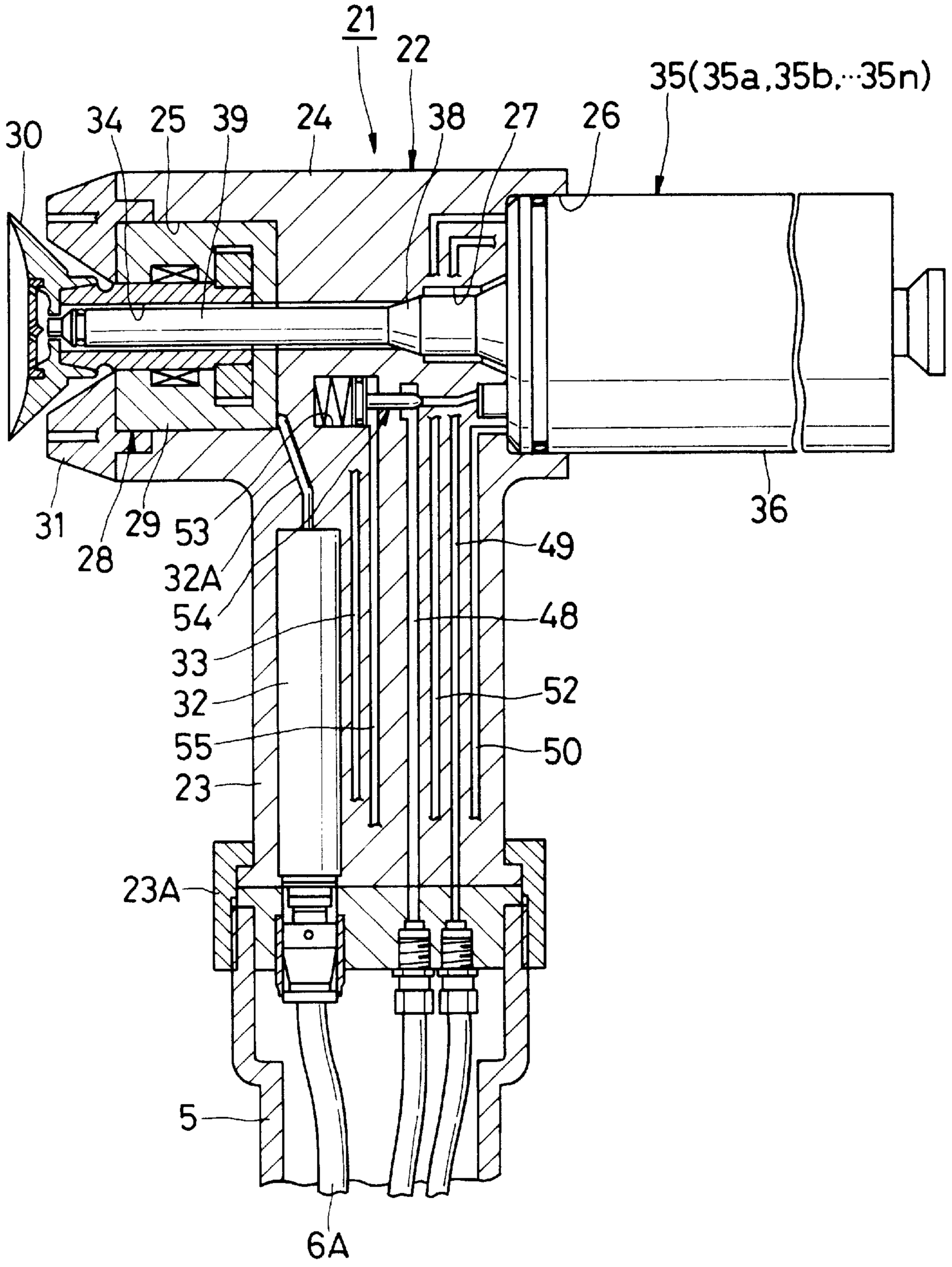
9A
8A
CONTROL AIR SOURCE
EJECTION AIR SOURCE
VACUUM SOURCE
7
9
8

Fig. 2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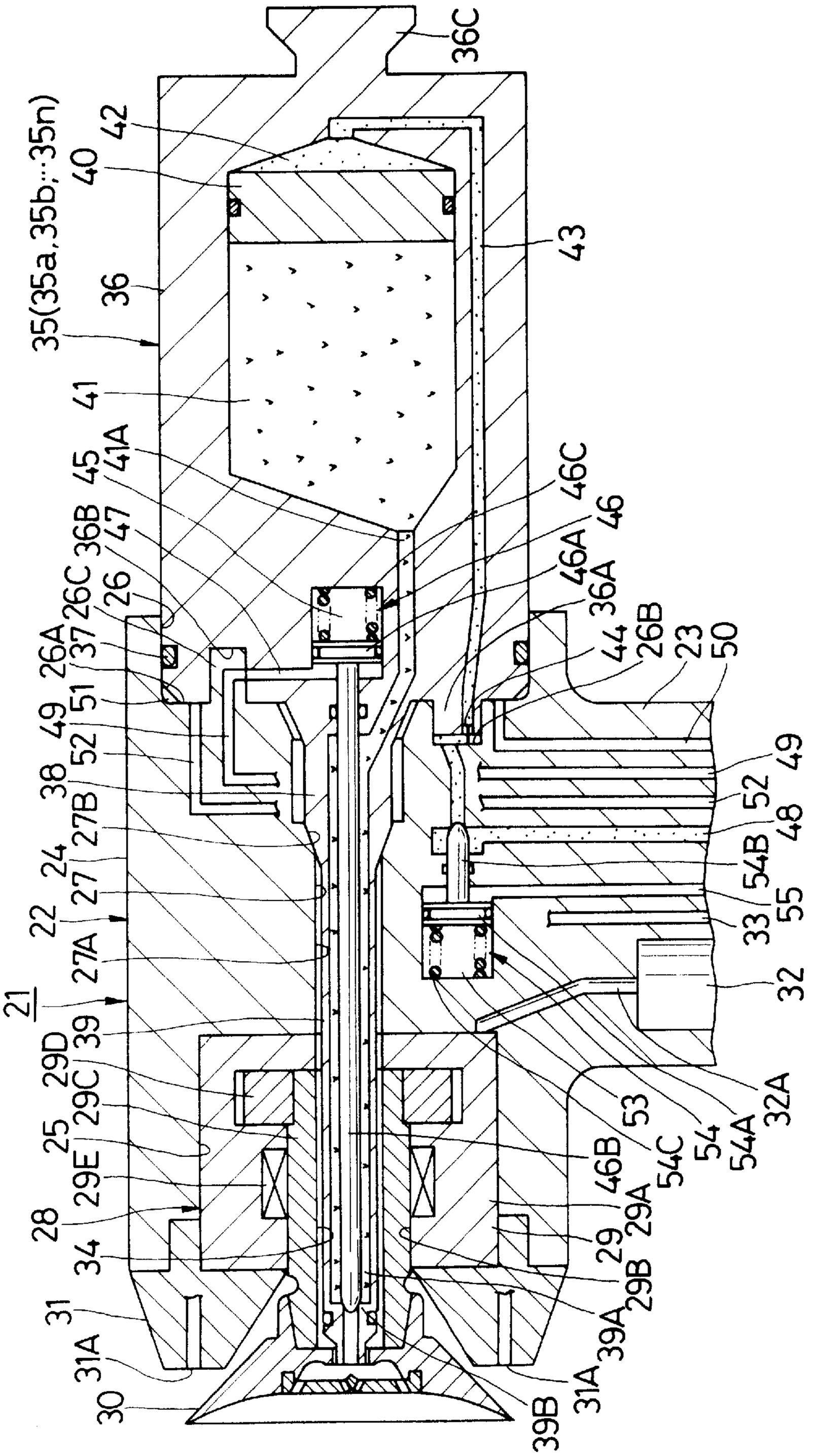
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29D
29C
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29E
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31
31A
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46C
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46A
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26B
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39A
39B
31A

Fig. 3

Fig. 4

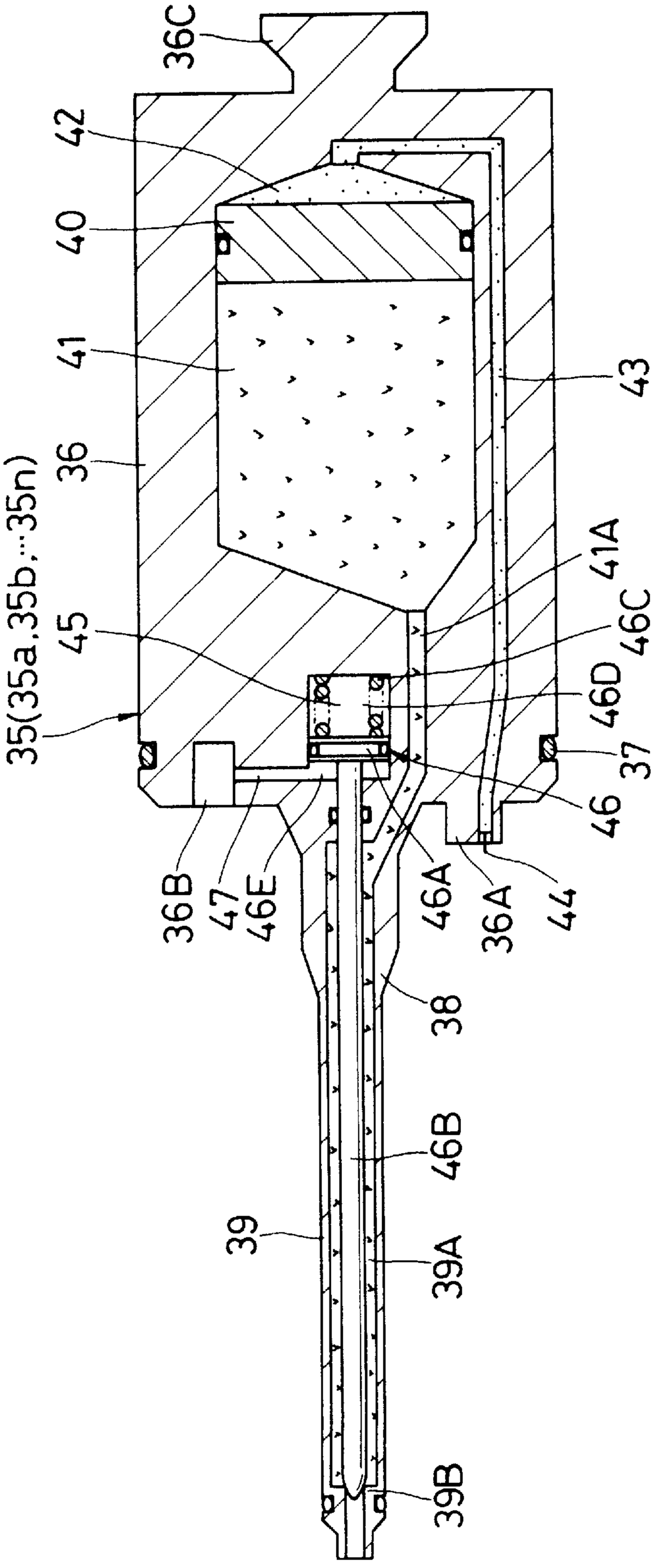
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Fig. 5

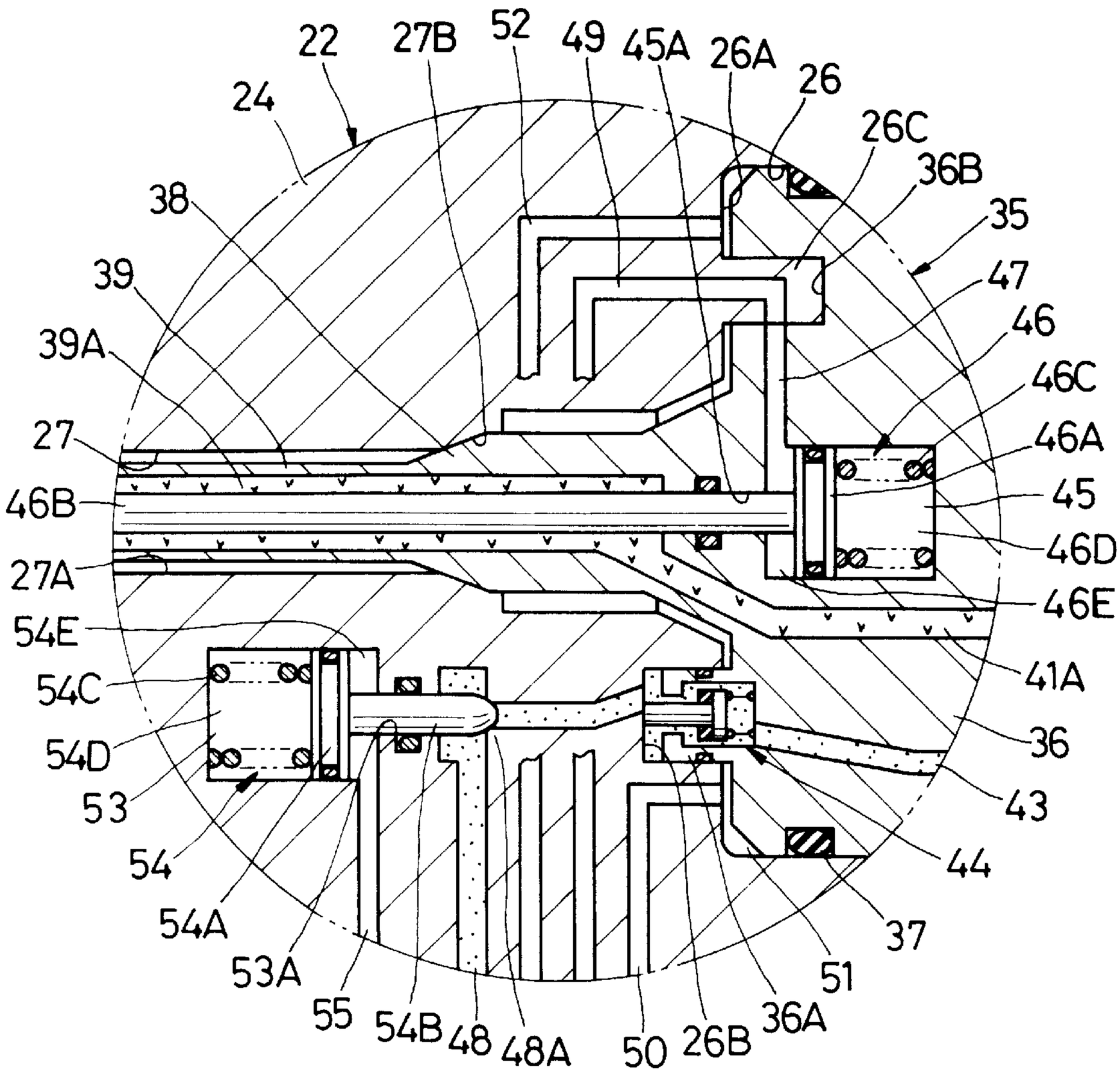
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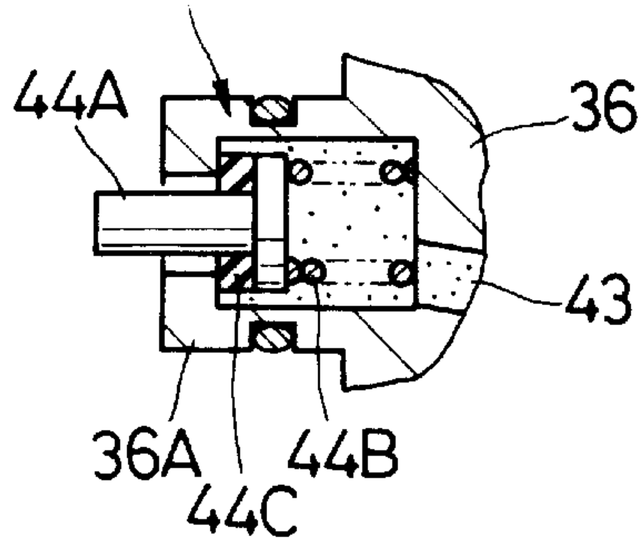
Fig. 6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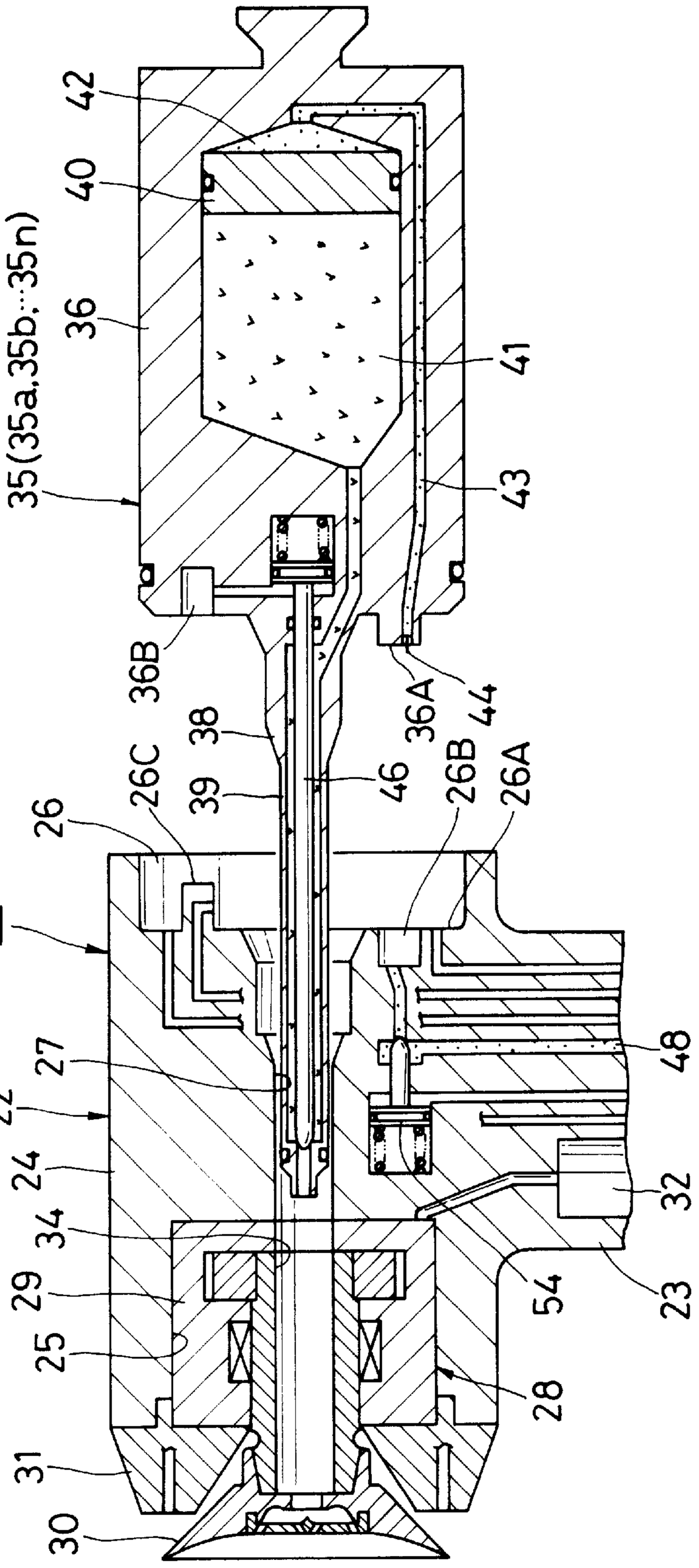
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Fig. 7

Fig. 8

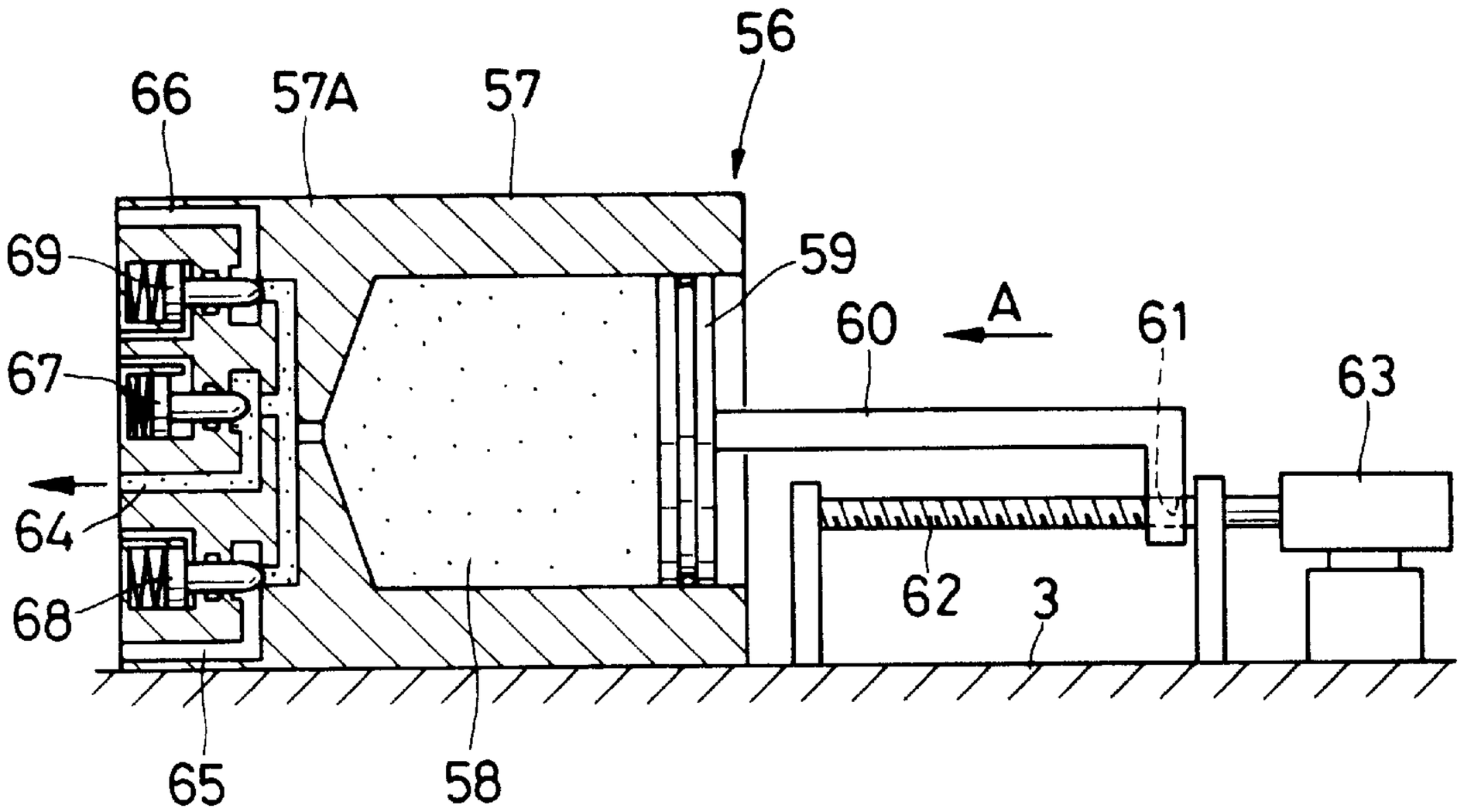
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Fig. 9

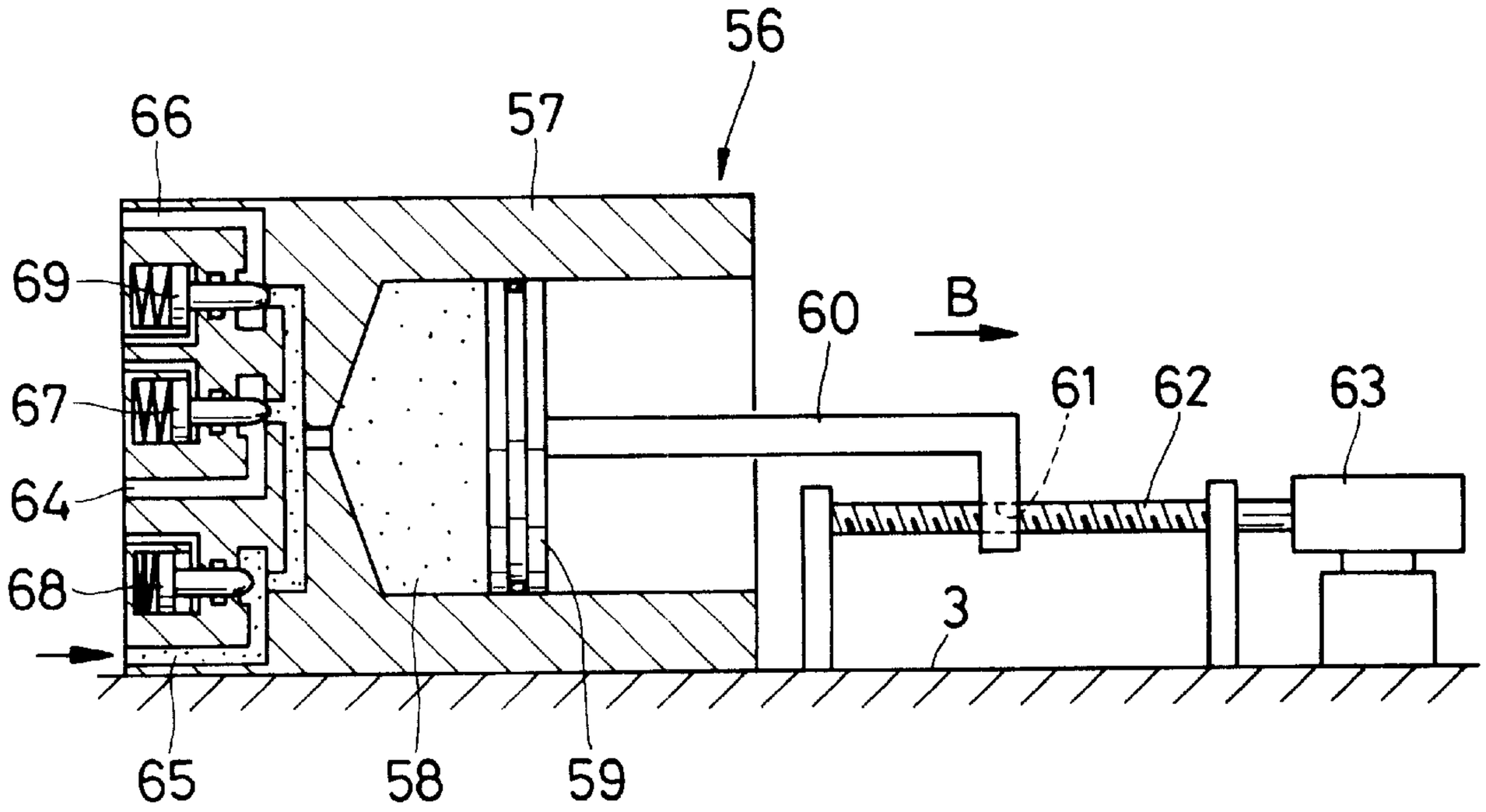
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Fig. 10

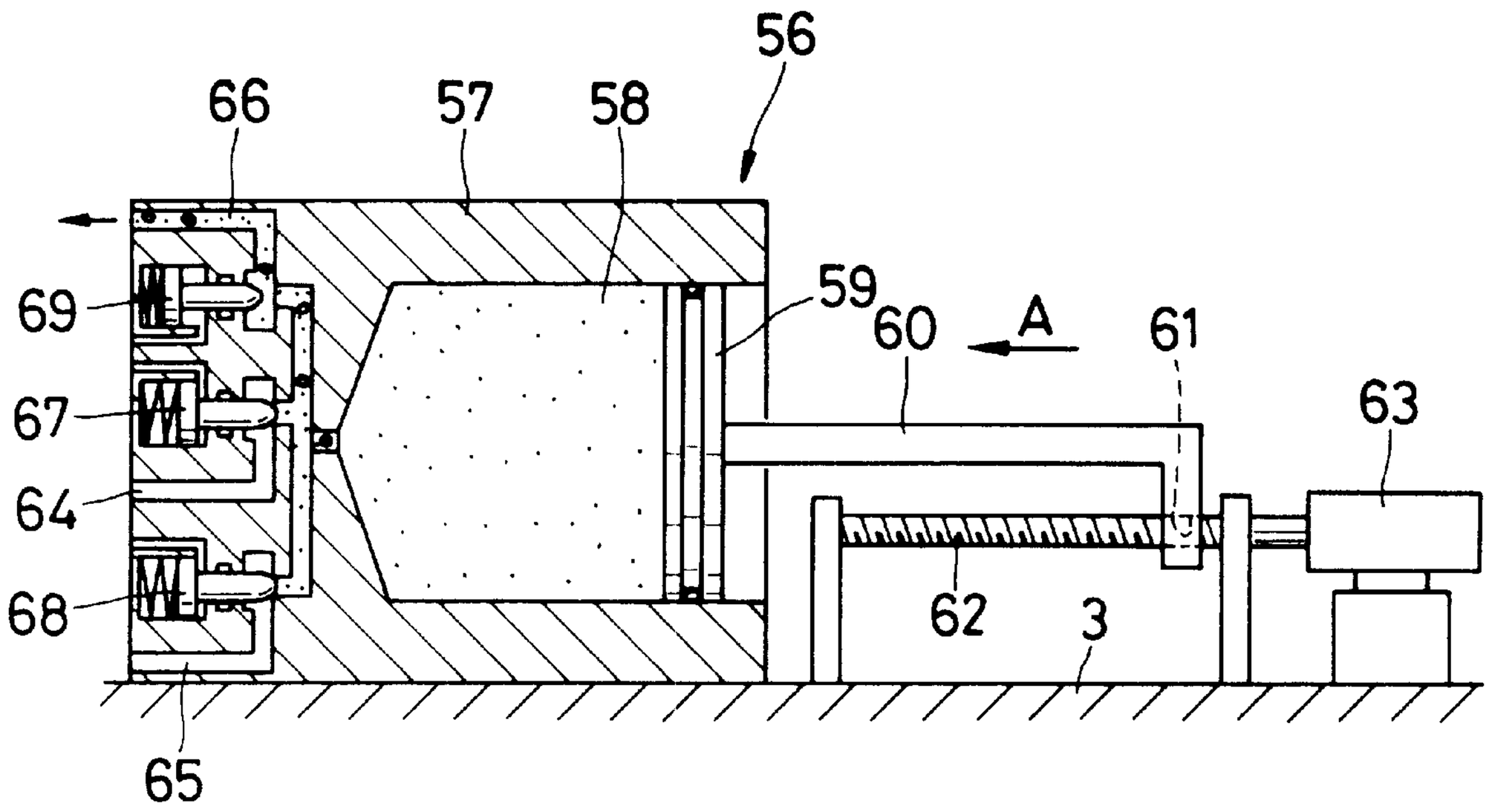
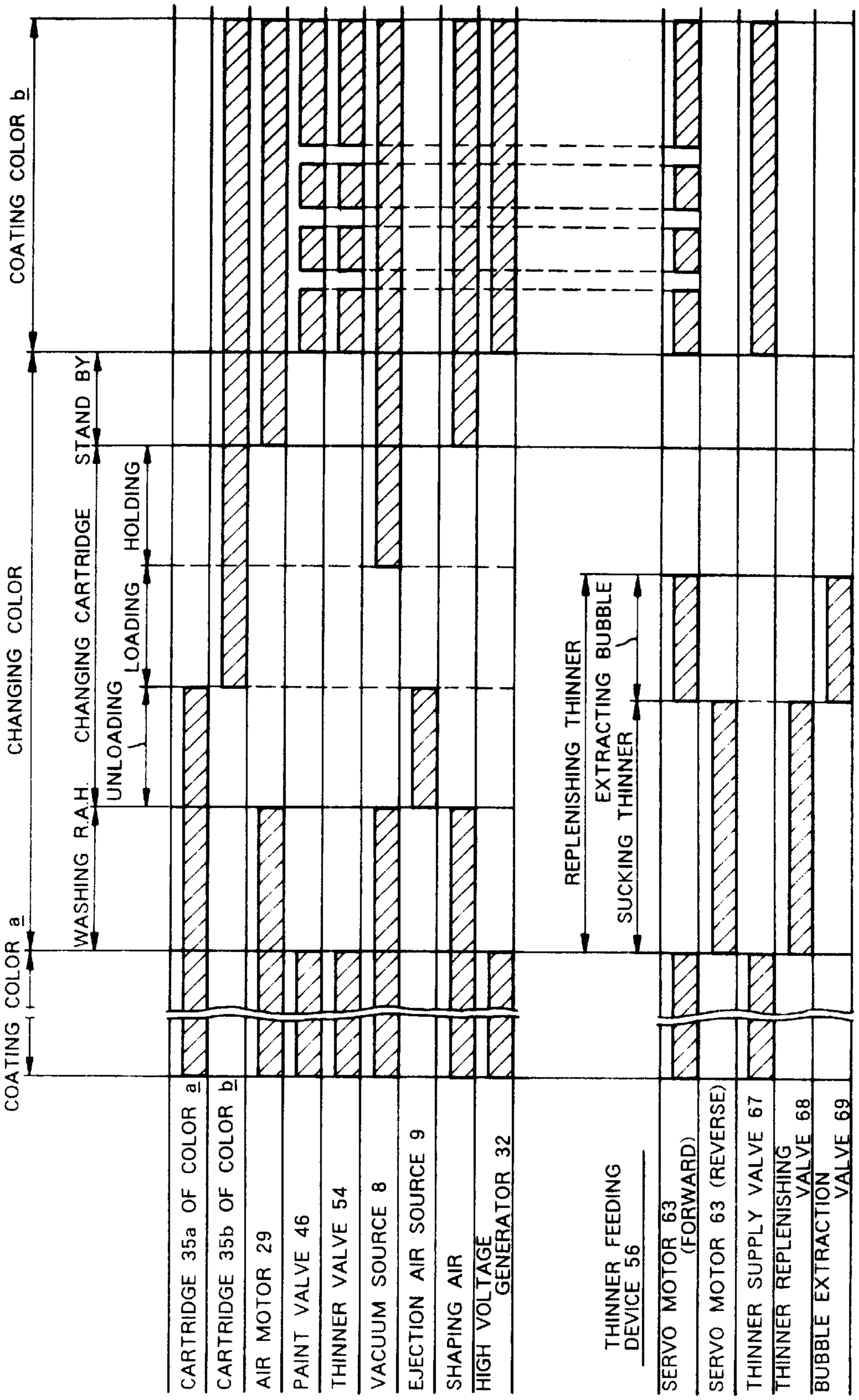


Fig. 11


CHANGING COLOR
COATING COLOR b
CHANGING CARTRIDGE
STAND BY
UNLOADING
LOADING
HOLDING
WASHING R.A.H.
COATING COLOR a
REPLENISHING THINNER
EXTRACTING BUBBLE
SUCKING THINNER
CARTRIDGE 35a OF COLOR a
CARTRIDGE 35b OF COLOR b
AIR MOTOR 29
PAINT VALVE 46
THINNER VALVE 54
VACUUM SOURCE 8
EJECTION AIR SOURCE 9
SHAPING AIR
HIGH VOLTAGE GENERATOR 32
THINNER FEEDING DEVICE 56
SERVO MOTOR 63 (FORWARD)
SERVO MOTOR 63 (REVERSE)
THINNER SUPPLY VALVE 67
THINNER REPLENISHING VALVE 68
BUBBLE EXTRACTION VALVE 69

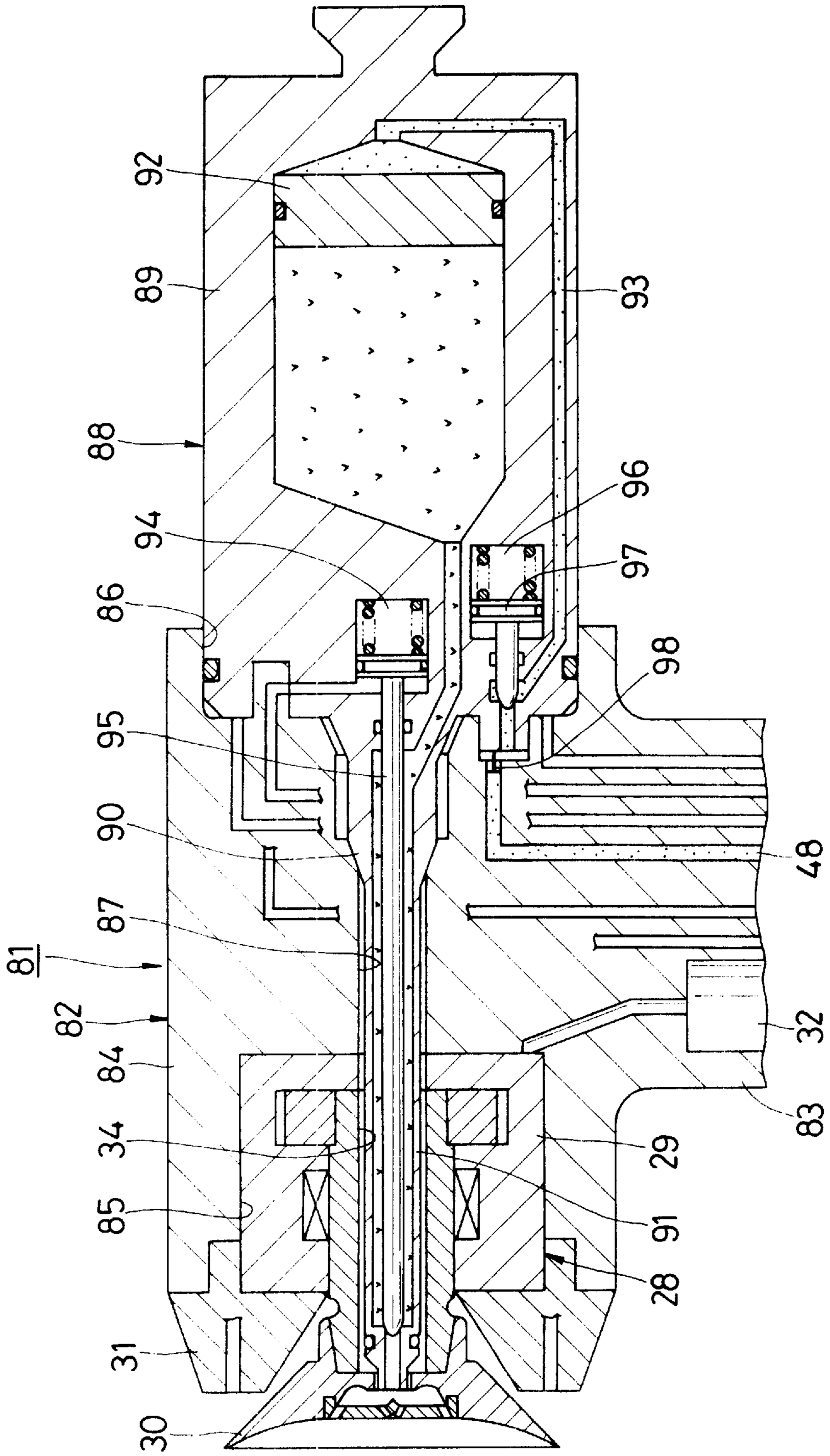

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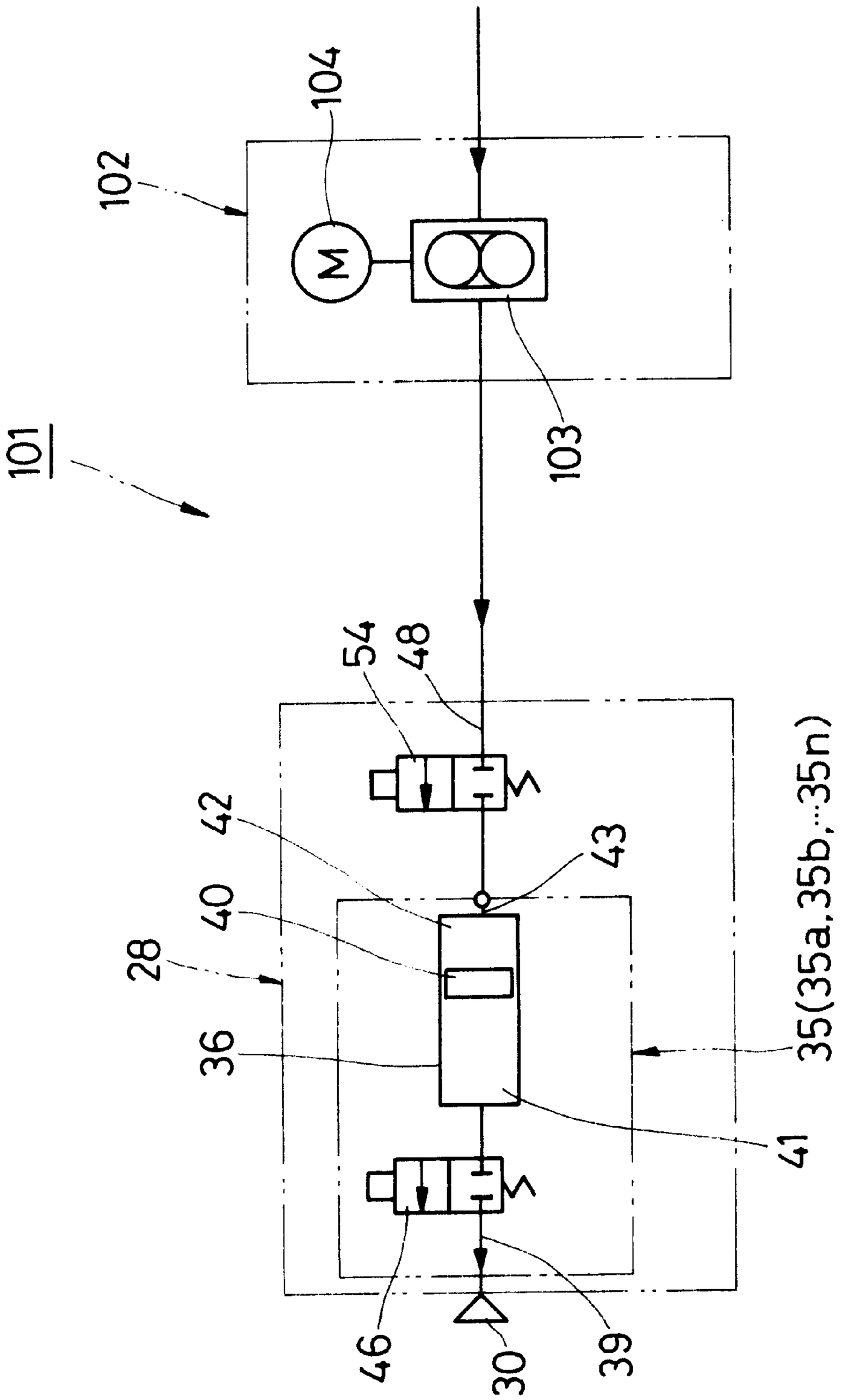
Fig. 12

Fig. 13



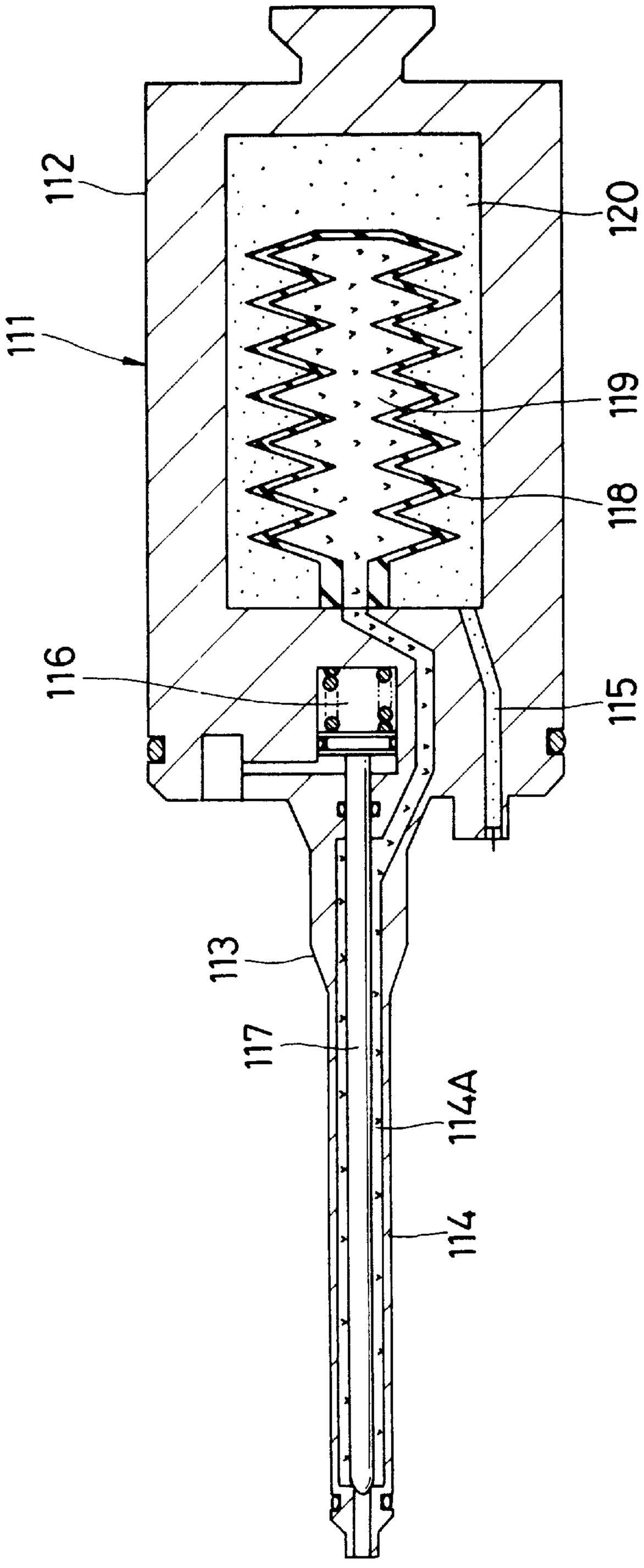
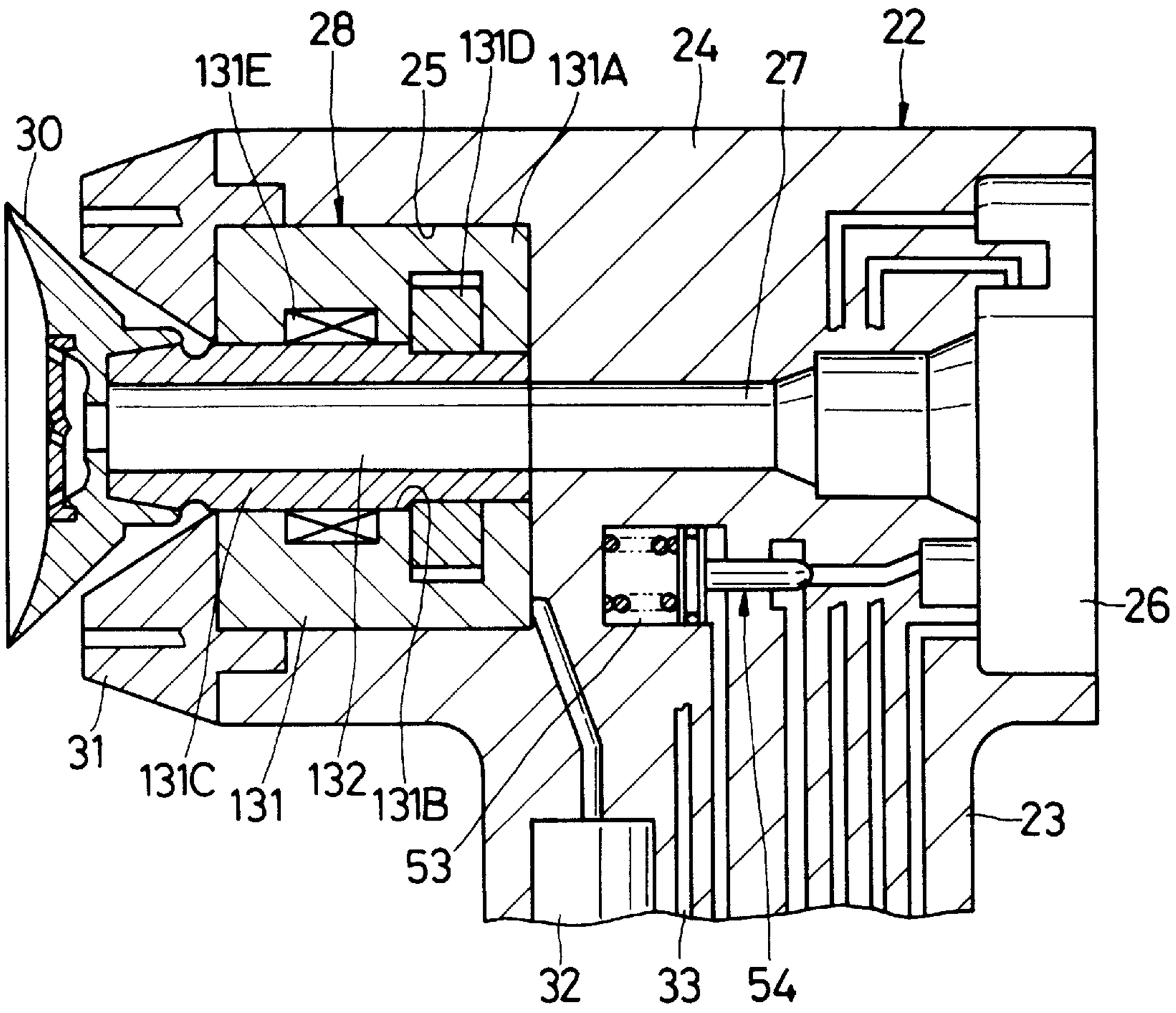


Fig. 14

Fig. 15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ROTARY ATOMIZING HEAD TYPE COATING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a rotary atomizing head type coating system, particularly suitable for use, for example, in coating operations on vehicle bodies or the like which require changes of paint colors.

2. Discussion of the Background

Generally, rotary atomizing head type coating systems have been in wide use for coating vehicle bodies and the like. In connection with coating operations of this sort, recent demands are mostly focused on measures for reducing the amounts of paint and solvent which have to be discarded as waste each time when changing the paint color as well as on measures for coping with as many color changes as possible in the course of a coating operation.

In this regard, Japanese Laid-Open Patent Publication No. H8-229446 discloses a rotary atomizing head type coating system which is provided with measures for reducing the amounts of waste paint and solvent, and which can cope with an increased number of paint colors. This rotary atomizing head type coating system employs paint cartridges of different colors which can be replaceably set in position within a housing together with a coating machine unit.

Further, the prior art rotary atomizing head type coating system is generally composed of a housing which is provided with a coating machine mount portion and a cartridge mount portion in its front and rear portions, respectively, and a coating machine which is mounted in the coating machine mount portion, including an air motor with a rotational shaft and a rotary atomizing head which is mounted on a fore end portion of the rotational shaft of the air motor. Provided internally of and axially through the rotational shaft of the air motor, which constitutes the coating machine, is a feed tube passage having its fore and rear ends opened into the rotary atomizing head and the cartridge mount portion, respectively.

The coating system is equipped with paint cartridges of different colors which are selectively and replaceably mounted on the cartridge mount portion of the housing. Each one of the paint cartridges is constituted by a cylinder which is filled with paint and a feed tube which is extended axially forward from the fore distal end of the cartridge cylinder. The cartridge cylinder is replaceably set in position within the cartridge mount portion on the housing, while the feed tube is passed through the above-mentioned feed tube passage.

The paint cartridge is further provided with a movable partition wall defining within the cartridge cylinder a paint reservoir chamber in communication with the feed tube and a paint-extruding air chamber, and an air passage which supplies paint-extruding air to the air chamber. In addition, to and in communication with the air passage on the side of the cartridge, an air passage is also provided on the side of the housing. Through the air passage on the side of the housing and the air passage on the side of the cartridge, paint-extruding air is circulated to the paint-extruding air chamber to displace the movable partition wall forward, thereby pushing the paint in the paint reservoir chamber into the rotary atomizing head through the feed tube.

In the case of the prior art rotary atomizing head type coating system which is arranged in the above-described manner, a paint cartridge of a particular color, which is selected from a number of cartridges of different colors, is mounted on the cartridge mount portion in the housing. Then, air is supplied to the paint-extruding air chamber of the cartridge under suitable pressure to push forward the paint in the paint reservoir chamber of the paint cartridge into the feed tube for supplying to the rotary atomizing head, which sprays the supplied paint over an article to be coated.

The paint color can be changed simply by replacing the cartridge on the machine by other paint cartridge of a different color, without necessitating to discard waste paint and solvent.

During a coating operation, the rotary atomizing head type coating system according to the above-described prior art is put in reciprocating movements and at the same time its position is successively shifted in a direction perpendicular to the direction of reciprocating movements. At this time, in order to maintain a uniform thickness of the coating film, the movement of the coating system is reversed at positions outside a coating surface of work. Besides, as the coating system comes to a position outside a coating surface, the supply of air to an air chamber of the paint cartridge is cut off to break the paint supply to the rotary atomizing head, thereby temporarily stopping paint spraying from the atomizer head.

However, even if the air supply is cut off to stop paint spraying, it is often the case that the air passages and air chamber remain in a pressurized state for some time after the air supply is cut off. Therefore, during that time period, the movable partition wall is displaced to continue the paint supply to the rotary atomizing head until the air passages and air chamber as well as the paint reservoir chamber and the feed tube settle down to a static pressure level.

Accordingly, after dispatching a command signal to stop the paint supply, there is always a time lag until the paint supply actually comes to a stop. This gives rise to various problems, for instance, such as wasteful paint consumption, paint depositions on unnecessary portions of coating surfaces, and irregularities in thickness of a coated film which would invite degradations in quality of the coating.

Further, when a paint cartridge is extracted from the housing for replacement, the residual paint which drips from the feed tube may fall on a coated surface to become a cause of coating defects.

Furthermore, the prior art coating system employs paint-extruding air for displacing the movable partition wall in the cartridge cylinder. However, a compressed fluid like air is apt to undergo variations in volume while being supplied to the extruding air chamber. Therefore, it is usually required to provide a flowmeter and various control valves additionally on the coating system in order to ensure accurate paint supply at the time of a coating operation, resulting in increases in size and running cost of the coating system.

SUMMARY OF THE INVENTION

In view of the problems of the prior art as described above, it is an object of the present invention to provide a rotary atomizing head type coating system which is capable of controlling paint spraying and stopping actions accurately by turning on and off the paint supply definitely in an assured manner.

It is another object of the present invention to provide a rotary atomizing head type coating system which can maintain a constant coating thickness and which can prevent paint dripping to ensure quality coatings.

In accordance with the present invention, there is provided a rotary atomizing head type coating system of the

type which basically includes: a housing having a coating machine mount portion on the front side and a cartridge mount portion on the rear side thereof; a coating machine adapted to be mounted on the coating machine mount portion of the housing, and having an air motor with a rotational shaft and a rotary atomizing head mounted on a front end portion of the air motor; a feed tube passage hole provided internally of and axially through the rotational shaft of the air motor, and having a front end opened into the rotary atomizing head and a rear end opened into the cartridge mount portion of the housing; and a plural number of paint cartridges containing paint of different colors in respective cartridge cylinders, each one of the paint cartridges being adapted to be selectively and detachably loaded on the cartridge mount portion of the housing and having a feed tube extended axially forward from a front end portion of the cartridge cylinder for placement in the feed tube passage hole.

In order to solve the above-described problems, the rotary atomizing head type coating system according to the present invention is characterized by the provision of: on the side of the paint cartridge, a movable partition wall dividing the cylinder into a paint reservoir chamber in communication with the feed tube and an extruding liquid chamber, an extruding liquid passage for supplying an extruding liquid to the extruding liquid chamber, and a paint valve to turn on and off paint supply from the feed tube to the rotary atomizing head; on the side of the housing, an extruding liquid passage in communication with the extruding liquid passage on the cartridge; and an extruding liquid valve provided within the length of the extruding liquid passage either on the side of the cartridge or on the side of the housing to turn on and off extruding liquid supply to the extruding liquid chamber.

With the arrangements just described, a paint cartridge is loaded on the cartridge mount portion of the housing prior to a coating operation, with the feed tube of the cartridge placed in the feed tube passage hole which is formed internally of the rotational shaft of the air motor. Then, the paint valve and the extruding liquid valve are opened, thereby displacing the movable partition wall by an extruding liquid which is introduced into the extruding liquid chamber in the cartridge through the extruding liquid passage on the side of the housing and the extruding liquid passage on the side of the cartridge. As the movable partition wall is displaced in this manner, the paint which is filled in the cartridge is pushed forward and delivered to the rotary atomizing head through the feed tube. On the other hand, since the rotary atomizing head is put in high speed rotation by the air motor, the supplied paint is atomized into fine particles and sprayed toward a coating object.

During a coating operation, the paint spray is usually turned on and off repeatedly depending upon the shapes of coating surfaces. For stopping or turning off the paint spray, the paint valve is closed to shut off the paint supply passage in the feed tube to hold the paint supply from the paint reservoir chamber to the rotary atomizing head. At the same time, the extruding liquid valve is closed to shut off the extruding liquid passage on the side of the housing or on the side of the paint cartridge to stop the supply of extruding liquid to the extruding liquid chamber. Therefore, when stopping the paint spray, the paint supply is immediately cut off by closure of the paint valve, and at the same time the supply of the extruding liquid is similarly immediately cut off by closure of the extruding liquid valve, making it possible to turn on and off the paint supply to the rotary atomizing head definitely in a reliable manner.

Further, when changing the paint color, a coating operation in a new color can be started simply after replacing a paint cartridge on the cartridge mount portion of the housing by a paint cartridge of a new color. During the cartridge replacement, the paint supply passage in the feed tube is shut off by the paint valve to prevent the paint from dripping from the feed tube.

In this instance, according to the present invention, it is preferred that the coating system further comprises an extruding liquid feeding means which is connected to the extruding liquid passage on the side of the housing to supply an extruding liquid quantitatively to the cartridge. With these arrangements, the movable partition wall is displaced by an extruding liquid, which is quantitatively fed to the extruding liquid chamber from the extruding liquid feeding means via the extruding liquid passage on the side of the housing and the extruding liquid passage on the side of the cartridge, to supply paint quantitatively from the feed tube to the rotary atomizing head.

According to the present invention, the coating system may further comprise a coating robot with vertical and horizontal arms, having the housing of the coating system mounted on a fore end portion of the horizontal arm of the coating robot while having the extruding liquid feeding means mounted on the vertical arm of the coating robot. With these arrangements, the extruding liquid feeding means can be located in a position in the vicinity of the housing and cartridge, which would neither put much burden on the coating robot nor require lengthy piping work.

Further, in one preferred form of the present invention, the extruding liquid feeding means is in the form of a positive displacement pump means constituted by a piston type pump having a cylinder and a piston, and a servo motor for displacing the piston within the cylinder of the pump.

With the arrangements just described, by rotating the servo motor at a predetermined rotational speed, the piston of the piston type pump can be displaced according to the rotational speed of the motor to feed the extruding liquid in the cylinder quantitatively to the cartridge.

Further, according to the present invention, preferably the extruding liquid feeding means comprises, in a fore end portion of the cylinder of the piston type pump and in communication with each other, an extruding liquid supply conduit connected to the extruding liquid passage on the side of the housing, an extruding liquid replenishing conduit connected to an extruding liquid source, and a drain conduit connected to a drain side, the extruding liquid supply conduit being provided with an extruding liquid supply valve to be opened only when the extruding liquid in the cylinder is supplied to the paint cartridge, the extruding liquid replenishing conduit being provided with a liquid replenishing valve to be opened only when the extruding liquid is replenished to the cylinder, and the drain conduit being provided with an air bubble extraction valve to be opened only when removing air bubbles from an extruding liquid replenished to the cylinder.

With the arrangements just described, among the extruding liquid valve, the extruding liquid replenishing valve and the air bubble extraction valve of the extruding liquid feeding means, when the extruding liquid valve alone is opened, the extruding liquid within the cylinder can be supplied to the paint cartridge through the extruding liquid supply conduit. On the other hand, when the extruding liquid replenishing valve is opened, the extruding liquid can be replenished to the cylinder through the extruding liquid replenishing conduit. Further, when the air bubble extraction

valve is opened, air bubbles which are trapped in the extruding liquid within the cylinder can be removed or expelled to the outside through the drain conduit.

Further, in another preferred form of the present invention, the extruding liquid feeding means is in the form of a positive displacement pump means constituted by a gear pump, and a servo motor which rotationally drives the gear pump. In this case, by rotating the servo motor at a predetermined rotational speed, the extruding liquid in the cylinder can be quantitatively supplied to the cartridge.

Further, according to the present invention, the paint valve and the extruding liquid valve are adapted to be open and close in synchronism with start and stop of the servo motor. With these arrangements, the paint valve and the extruding liquid valve can be controlled to open and close precisely and accurately in timed relation with start and stop of the servo motor. Accordingly, it also becomes possible to prevent paint drips from the feed tube which would otherwise occur due to residual pressures in the cylinder or other parts of the machine.

Further, according to the present invention, the paint valve is arranged as an air pilot operated control valve which is normally biased in a closing direction by a valve spring and adapted to open upon applying pilot air thereto from outside to open a paint flow through the feed tube. With these arrangements, the valve body of the paint valve is normally closed by the biasing force of the valve spring to shut off the paint supply passage. On the other hand, upon supply of pilot air, the valve body is opened against the biasing force of the valve spring to open a paint flow through the feed tube.

Further, according to the present invention, the extruding liquid valve is arranged as an air pilot operated control valve which is normally biased in a closing direction by a valve spring and opened upon application of pilot air thereto from outside to open an extruding liquid flow through the extruding liquid passage.

With the arrangements just described, the valve body of the extruding liquid is normally closed by the biasing force of the valve spring to shut off the extruding liquid passage. On the other hand, upon supply of pilot air, the valve body is opened against the biasing force of the valve spring to open an extruding liquid flow through the extruding liquid passage.

Further, according to the present invention, the cartridge mount portion of said housing is provided with a positioning coupler portion for engagement with a complementarily shaped positioning coupler portion on a front end portion of the cylinder of the paint cartridge.

With the arrangements just described, as the paint cartridge is loaded on the cartridge mount portion of the housing, the cartridge is located in a predetermined position on the cartridge mount portion by engagement of the positioning coupler portion on the side of the cartridge with the corresponding positioning coupler portion on the side of the housing.

Further, according to the present invention, the housing is provided with a vacuum space which is defined between the cartridge mount portion and the cylinder of the cartridge when the cylinder is mounted in position on the cartridge mount portion, and an air suction passage opened to the vacuum space to suck air out of the vacuum space, to holding the cartridge fixedly against the cartridge mount portion of the housing with suction force.

With the arrangements just described, upon loading the paint cartridge into the cartridge mount portion of the housing, air is sucked through the air suction passage to develop vacuum in a vacuum space which is formed between the cartridge mount portion of the housing and the cylinder of the paint cartridge, thereby holding the cartridge fixedly against the cartridge mounting portion. Upon supplying air to the vacuum space, the paint cartridge is released from the suction force and can be dismantled or unloaded from the housing.

According to the present invention, there may be provided another feed tube passage hole on the housing in coaxial relation with the above-mentioned feed tube in the rotational shaft.

Further, in a particular form of the present invention, an extruding liquid valve is provided in the extruding liquid passage on the side of the housing, and the extruding liquid passage on the side of the cartridge is provided with a valved quick coupling in an open terminal end portion thereof. The quick coupling is opened only when the paint cartridge is fully and fixedly coupled with the cartridge mount portion of the housing.

With the arrangements just described, as soon as the paint cartridge is loaded and fixed in position on the cartridge mounting portion, the quick coupling in the extruding liquid passage on the side of the cartridge is opened, thereby supplying the extruding liquid to the extruding liquid passage in the cartridge through the extruding liquid passage on the side of the housing. On the other hand, as soon as the paint cartridge is dismantled or unloaded from the cartridge mount portion of the housing, the quick coupling is shut off to close the outer open end of the extruding liquid passage on the side of the cartridge, thereby preventing the paint from dripping down therefrom.

Further, in another particular form of the present invention, the extruding liquid valve is provided in the extruding liquid passage on the side of said cartridge, and the extruding liquid passage on the side of the housing is provided with a valved quick coupling in an open terminal end portion thereof, the quick coupling being opened only when the paint cartridge is fully and fixedly coupled with the cartridge mount portion of the housing.

With the arrangements just described, similarly, as soon as the paint cartridge is loaded and fixed in position on the cartridge mounting portion, the quick coupling in the extruding liquid passage on the side of the housing is opened, thereby supplying the extruding liquid to the extruding liquid passage in the cartridge from the extruding liquid passage on the housing. On the other hand, as soon as the paint cartridge is dismantled or unloaded from the cartridge mount portion of the housing, the quick coupling is shut off to close the terminal open end of the extruding liquid passage on the side of the cartridge, thereby preventing the paint from dripping down therefrom.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a front view of a rotary atomizing head type coating system, adopted as a first embodiment of the present invention and shown together with a coating robot;

FIG. **2** is a vertical sectional view of the rotary atomizing head type coating system of the first embodiment;

FIG. **3** is a vertical sectional view on an enlarged scale of the rotary atomizing head type coating system shown in FIG. **2**;

FIG. **4** is a vertical sectional view of a paint cartridge;

FIG. **5** is a vertical sectional view on an enlarged scale of a paint valve and a thinner valve in FIG. **3**;

FIG. **6** is a vertical sectional view on an enlarged scale of a valved quick coupling shown in FIG. **5**;

FIG. **7** is a vertical sectional view of a paint cartridge removed from a housing;

FIG. **8** is a vertical sectional view of a thinner feeding means employed in the first embodiment;

FIG. **9** is a vertical sectional view of the thinner feeding means in a thinner replenishing phase;

FIG. **10** is a vertical sectional view of the thinner feeding means in an air bubble stripping phase;

FIG. **11** is an operational time chart of the rotary atomizing head type coating system;

FIG. **12** is a vertical sectional view of a rotary atomizing head type coating system, adopted as a second embodiment of the present invention;

FIG. **13** is a circuit diagram employed in a third embodiment of the rotary atomizing head type coating system according to the present invention;

FIG. **14** is a vertical sectional view of a paint cartridge employed in a modification of the present invention; and

FIG. **15** is a vertical sectional view of an air motor and a housing employed in a modification of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereafter, with reference to the accompanying drawings, the present invention is described more particularly by way of its preferred embodiments of the rotary atomizing head type coating system, mounted on a coating robot.

Referring first to FIGS. **1** through **11** which show a first embodiment of the present invention, indicated at **1** is a coating robot serving as a working mechanism. The coating robot **1** is largely constituted by a pedestal or base **2**, a vertical arm **3** which is rotatably and rockably mounted on the base **1**, a horizontal arm **4** which is pivotally connected to the fore distal end of the vertical arm **3**, and a wrist portion **5** which is provided at the fore distal end of the horizontal arm **4**.

Further, connected to the coating robot **1** are various operating power and fluid sources, including a power supply **6** which is connected through a power supply line **6**A, a control air source **7** which is connected through an air hose **7**A, a vacuum source **8** which is connected as a vacuum generating means for a vacuum pump, ejector or the like through a vacuum hose **8**A, an ejection air source **9** which is connected through an air hose **9**A, a paint valve pilot air source **10** which is connected through an air hose **10**A, a thinner valve pilot air source **11** which is connected through an air hose **11**A, and a thinner reservoir **12** which is connected through a thinner hose **12**A to serve as an extruding liquid source. The power supply line **6**A and the hoses **7**A, **8**A, **9**A, **10**A and **11**A are extended as far as the wrist **5** through the vertical and horizontal arms **3** and **4**, and connected to the rotary atomizing head type coating system **21** which will be described hereinlater. The thinner hose **12**A is passed through the vertical arm **3** and connected to a thinner feeding device **56** as will be described hereinafter.

Indicated at **21** is the rotary atomizing head type coating system (hereinafter referred to simply as "coating system" for brevity) which is mounted on the coating robot **1**. As seen in FIGS. **2** and **3**, the coating system **21** is largely constituted by a housing **22**, a coating machine **28**, feed tube passage holes **27** and **34**, a paint cartridge **35**, a piston **40**, thinner passages **43** and **48**, a paint valve **46** and a thinner valve **54**.

The housing **22** is formed of an engineering plastic, for example, such as PTFE, PEEK, PEI, POM, PI, PET or the like, and attached to the fore distal end of the wrist **5**. The housing **22** is constituted by a neck portion **23** to be detachably fixed to the wrist **5** of the coating robot **1** through a clamp member **23**A, and a head portion **24** which is formed at and with the fore distal end of the neck portion **23**.

In this instance, a coating machine mount portion **25** and a cartridge mount portion **26**, both of a hollow cylindrical shape, are formed on the front and rear sides of the head portion **24**, respectively. Further, a female connector portion **26**B and a male connector portion **26**C are formed separately in a bottom portion **26**A of the cartridge mount portion **26**. The female connector portion **26**B is coupled with a male connector portion **36**A of a cartridge cylinder **36**, which will be described hereinafter, while the male connector portion **26**C is coupled with a female connector portion **36**B of the cartridge cylinder **36**. The female and male connector portions **26**B and **26**C of the cartridge mount portion **26** function as positioning coupler portions which determine the position of the cylinder **36** in the circumferential direction when connected and coupled therewith.

Denoted at **27** is the feed tube passage hole on the side of the housing, which is provided to extend between and in communication with the coating machine mount portion **25** and the cartridge mount portion **26** of the housing. The feed tube passage hole **27** includes a feed tube passage portion **27**A of a small diameter which is located on the front side, and a tapered conical recess **27**B which is located on the rear side. In this instance, the feed tube passage portion **27**A is formed in coaxial relation with a feed tube passage on the side of the coating machine, which will be described hereinafter. The conical recess **27**B functions as a positioning coupler section to hold the paint cartridge **35** in position in axial and radial directions by fitting engagement with a conical recess **38** on the cartridge **35** as will be described hereinafter.

Indicated at **28** is the coating machine which is fitted in the coating machine mount portion **25** of the head portion **24**. The coating machine **28** is largely constituted by an air motor **29**, a rotary atomizing head **30** to be put in rotation by the air motor **29**, and a shaping air ring **31** which is provided on the front side of the air motor **29**.

In this instance, the air motor **29** is constituted by a motor case **29**A to be fitted into the coating machine mount portion **25**, a stepped axial bore **29**B which is formed axially through the motor case **29**A and varied stepwise in diameter in the axial direction to provide a front large diameter portion and a rear small diameter portion, a rotational shaft **29**C which is extended axially through the large diameter portion of the axial bore **29**B and projected forward of the motor case **29**A at its fore end, an air turbine **29**D which is securely fixed to the rear end of the rotational shaft **29**C, and a static-pressure air bearing **29**E which is provided in the motor case **29**A and located around the large diameter portion of the axial bore **29**B in small gap relation with the rotational shaft **29**C.

Designated at **30** is the rotary atomizing head which is mounted on the air motor **29** at a fore distal end portion of the rotational shaft **29**C. The rotary atomizing head **30** is rotated by the air motor **29**. When the rotary atomizing head **30** is put in high speed rotation, paint is sprayed from the rotary atomizing head **30** in the form of finely atomized particles, and, as will be described hereinafter, paint particles which are charged with a high voltage are urged to fly toward and deposit on a coating object, traveling along an electrostatic field which is formed between the coating machine and the coating object.

Indicated at **31** is the shaping air ring which is attached to the coating machine mount portion **25** of the head portion **24**

in such a way as to hold the air motor **29** fixedly in position from the front side. The shaping air ring **31** is provided with a large number of shaping air outlet holes **31**A annularly on and around the outer peripheral side thereof. Through these shaping air outlet holes **31**A, shaping air is spurted out toward paint releasing edges of the rotary atomizing head **30** for shaping charged paint particles into a predetermined spray pattern as soon as they are released from the rotary atomizing head **30**.

Denoted at **32** is a high voltage generator which is provided in the neck portion **23** of the housing **22**. This high voltage generator **32** is constituted, for example, by a Cockcroft circuit which is arranged to elevate a source voltage, which is supplied from the power supply **6** through the power cable **6**A, to a level between −60 kV and −120 kV. Through a high voltage cable **32**A, for example, the output side of the high voltage generator **32** is electrically connected to the air motor **29**, so that a high voltage is applied to the rotary atomizing head **30** from the high voltage generator **32** through the rotational shaft **29**C of the air motor **29** for charging the paint directly. Alternatively, in a case where sprayed paint particles are to be charged indirectly by means of an external charging system, the output voltage of the high voltage generator **32** is directly supplied to an external electrode which is provided on or in the vicinity of the shaping air ring **31**.

Indicated at **33** are a plural number of air passages which are provided in the neck portion **23** of the housing **22**, and which are connected to the control air source **7** through the air hose **7**A. These air passages **33** supply turbine air, bearing air, brake air and shaping air. In this particular embodiment, one air passage alone is shown to represent a plural number of air passages.

In this instance, a turbine air passage supplies air to the air turbine **29**D of the air motor **29**. A bearing air passage supplies air to the static-pressure air bearing **29**E of the air motor **29**. A brake air passage supplies braking air to the air turbine **29**D to brake its rotation. Further, a shaping air passage supplies air toward the shaping air outlet holes **31**A of the shaping air ring **31**.

Denoted at **34** is a feed tube passage hole on the side of the coating machine, which is extended axially through the rotational shaft **29**C and motor case **29**A of the air motor **29**. The feed tube passage hole **34** on the side of the coating machine is opened at its rear or base end into a feed tube passage portion **27**A of the feed tube passage hole **27** on the side of the housing, and at its front end into the rotary atomizing head **30**. Further, the feed tube passage hole **34** on the side of the coating machine is formed coaxially aligned relation with the feed tube passage portion **27**A of the feed tube passage hole **27** on the side of the housing. A feed tube **39** of a paint cartridge **35** is extractably fitted in these feed tube passage holes **27** and **34**.

Indicated at **35***a*, **35***b* . . . **35***n* are paint cartridges of color a, color b and color n (hereinafter referred to collectively as "paint cartridges **35**" for the convenience of explanation), respectively, which hold different paint colors separately and independently for supply to the rotary atomizing head **30**. Each one of these paint cartridges **35** is arranged to be inserted into the feed tube passage holes **27** and **34** to supply paint of a particular color independently to the rotary atomizing head **30**. As shown in FIG. **4**, the cartridges **35** are largely constituted by a cylinder **36**, a conical nose-like projection **38** which is provided on the front end face of the cartridge cylinder **36**, a feed tube **39** which is extended axially forward from the conical projection **38** to provide therein a paint passage **39**A leading from the cartridge cylinder **36**, a piston **40** which is fitted in the cartridge cylinder **36** as a movable partition wall, and a thinner passage **43** which is provided on the side of the paint cartridge to supply thinner as a paint extruding liquid.

The cartridge cylinder **36**, a main body of the paint cartridge **35**, is formed of an engineering plastic similarly to the housing **22** and in the shape of a cylinder of a suitable diameter which can be detachably fitted in the cartridge mount portion **26** of the housing. An O-ring **37** is fitted in a fore position on the outer periphery of the cartridge cylinder **36** to hermetically seal the gap space between the cylinder **36** and the cartridge mount portion **26**. Further, a male connector portion **36**A and a female connector portion **36**B are provided at the fore end of the cylinder **36** in confronting positions relative to the female and male connector portion **26**B and **26**C on the part of the cartridge mount portion **26**, respectively. In addition, the cylinder **36** is provided with a grip portion **36**C at its rear end, which is gripped by an operator when mounting or dismantling the paint cartridge **35**. The male and female connector portions **36**A and **36**B also function as positioning coupler portions which determine the position in the circumferential direction of the cartridge cylinder **36** on the cartridge mount portion **26**.

Indicated at **38** is a conical coupling projection which is formed integrally with the cartridge cylinder **36**. When the cartridge **35** is mounted on the cartridge mount portion **26** of the housing **22**, the conical projection **38** is coupled with the conical coupling recess **27**B to determine the position of the paint cartridge **35** in both axial and radial directions.

Indicated at **39** is a feed tube which is provided at a fare end of the concial coupling projection **38**. A feed tube **39** is formed coaxially a paint supply passage **39**A. The base or rear end of the paint supply passage **39**A is connected to a paint reservoir chamber **41** which will be described hereinafter, while its fore end is opened toward the rotary atomizing head **30**. The feed tube **39** is provided with a valve seat portion **39**B which is formed by reducing the diameter of a fore end portion of the paint supply passage **39**A. A valve body **46**B of a paint valve **46**, which will be described hereinafter, is seated on and off the valve seat portion **39**B. The feed tube **39** has such a length that its fore distal end is extended into the rotary atomizing had **30** when the cartridge **35** is loaded in position on the cartridge mount portion **26** of the housing **22**.

On the other hand, a piston **40** is fitted in the cylinder **36** for sliding movements in the axial direction. By the piston **40**, the cartridge cylinder **36** is partitioned into a paint reservoir chamber **41**, which is communicated with the paint supply passage **39**A of the feed tube **39** through a communication passage **41**A, and a thinner chamber **42** as a paint-extruding liquid chamber which holds thinner as a paint-extruding liquid.

Indicated at **43** is a thinner passage which is formed on the side of the cartridge as a passage for an extruding liquid. The thinner passage **43** on the side of the cartridge is formed axially in and along the outer periphery of the cylinder **36**. One end of the thinner passage **43** is opened in the fore end face of the male connector portion **36**A of the cylinder **36**, while the other end is communicated with the thinner chamber **42**. Through the thinner passage **43** on the side of the cartridge, thinner is supplied to the thinner chamber **42** to push the piston **40** forward or toward the feed tube **39**. By this movement of the piston **40**, the paint which is filled in the paint reservoir chamber **41** is extruded toward the rotary atomizing head **30**.

The thinner which is used as a paint-extruding liquid is selected from a electrically insulating type or from a high resistance type in order to prevent leaks through the thinner of the high voltage which is applied by the high voltage generator **32**. As an extruding liquid, the thinner contributes to keep the inner wall surfaces of the cylinder **36** constantly in a wet state, preventing the paint from getting dry and sticking thereto when the piston **40** is displaced therein. Consequently, thanks to stabilization of the frictional resistance in the sliding contact between the piston **40** and the cylinder **36**, the piston **40** can be moved very smoothly. In addition, the hermetical seal between the piston **40** and the cylinder **36** can be improved in tightness.

Indicated at **44** is a valved quick coupling which is provided at the open end of the thinner passage **43** in the male connector portion **36**A on the paint cartridge **36**. The valved quick coupling **44** is arranged as a check valve including the afore-mentioned male connector portion **36**A of the cylinder **36**. As shown in FIG. **6**, the quick coupling **44** is largely constituted by the male connector portion **36**A, a valve body **44**A of a stepped cylindrical shape which has a fore end portion projected on the front side of the male connector portion **36**A, a coil spring **44**B biasing the valve body **44**A in the projecting direction, and a resilient ring **44**C of rubber or the like which is provided on the outer periphery of the valve body **44**A to seal the gap space between the valve body **44**A and the male connector portion **36**A.

The quick coupling **44** is opened to communicate the thinner passage **43** on the side of the cartridge with a thinner passage **48** on the side of the housing, which will be described hereinafter, to permit circulation of the thinner only when the cartridge **35** is attached to the cartridge mount portion **26** and the male connector portion **36**A is coupled with the female connector portion **26**B until the fore end of the valve body **44**A of the quick coupling **44** is abutted against the bottom of the female connector portion **26**B as shown in FIG. **5**.

On the other hand, when the cartridge **35** is dismantled from the cartridge mount portion **26**, disengaging the male connector portion **36**A from the female connector portion **26**B as shown in FIG. **7**, the valve body is pushed against the valve seat by the coil spring **44**B along with the resilient ring **44**C to close the thinner passage **43** on the side of the cartridge, thereby preventing thinner from flowing out of the thinner passage **43**.

Indicated at **45** is a paint valve receptacle portion which is provided at the front end of the cartridge cylinder **36**, the paint valve receptacle portion **45** being in the form of a round bore which is located in coaxial relation with the feed tube **39**. A valve receiving bore **45**A is provided axially in the paint valve receptacle portion **45** in communication with the paint supply passage **39**. As described below, a paint valve **46** is accommodated in the paint valve receptacle portion **45**.

The paint valve **46**, which is provided on the cartridge **35**, is opened when the paint in the paint reservoir chamber **41** is to be fed to the rotary atomizing head **30**. The paint valve **46** is constituted by a piston **46**A which is slidably fitted in the paint valve receptacle portion **45**, an elongated valve body **46**B which is attached to the piston **46**A at its base end and extended through the paint supply passage **39**A of the feed tube **39** through the valve receiving bore **45**A to seat on and off a valve seat **39**B at its fore end, and a valve spring **46**C biasing the valve body **46**B in the seating direction through the piston **46**A. Further, by the piston **46**A, the paint valve receptacle portion **45** is divided into a spring chamber **46**D, which accommodates the above-described valve spring **46**C, and a pressure receiving chamber **46**E to which pilot air is introduced. Thus, the paint valve **46** is constituted as an air pilot operated control valve.

Normally, the valve body **46**B of the paint valve **46** is seated on the valve seat **39**B of the feed tube **39** under the influence of the biasing action of the valve spring **46**C, shutting off the paint supply passage **39**A to stop the paint supply to the rotary atomizing head **30**. On the other hand, when pilot air is supplied to the pressure receiving chamber **46**E from a paint valve pilot air source **10** through the air hose **10**A, the pilot air passage **49** on the side of the housing and the pilot air passage **47** on the side of the cartridge, the valve body **46**B of the paint valve **46** is unseated from the valve seat **39**B against the action of the valve spring **46**C to supply paint in the paint reservoir chamber **41** to the rotary atomizing head **30**. In this instance, one end of the pilot air passage **47** is opened to the inner periphery of the female connector portion **36**B of the cylinder **36**, while the other end of the pilot air passage is communicated with the pressure receiving chamber **46**E of the paint valve **46**.

Indicated at **48** is a thinner passage which is provided on the side of the housing **22** as an extruding liquid passage. As shown in FIG. **5**, the thinner passage **48** is extended axially through the neck portion **23** and bent rearward in the shape of letter L at the position of a valve receiving bore **53**A of a thinner valve receiving portion **53**. This thinner passage **48** on the side of the housing has one end connected to a thinner feeding device **56**, which will be described hereinafter, and has the other end opened in a bottom portion of the female connector portion **26**B of the cartridge mount portion **26**. Besides, the bent portion of the thinner passage **48** on the side of the housing forms a valve seat **48**A on which a valve member **54**B of a thinner valve is to be seated on and off.

Designated at **49** is a pilot air passage which is provided on the side of the housing **22**. One end of this pilot air passage **49** is connected to the paint valve pilot air source **10** through the air hose **10**A. The other end of the pilot air passage **49** is opened on the circumferential surface of the male connector portion **26**C which is provided on the bottom portion **26**A of the cartridge mount portion **26** at a position where it meets the pilot air passage **47** on the side of the paint cartridge.

Indicated at **50** is an air suction passage which is provided on the housing **22** and opened to the bottom portion **26**A of the cartridge mount portion **26**. This air suction passage **50** is connected to a vacuum source **8** through a vacuum hose **8**A. The paint cartridge **35** is drawn to and fixed against the cartridge mount portion **26** by the vacuum force of the air suction passage which sucks air in a vacuum space **51** (FIG. **5**) which is defined between the deepest portion of the cartridge mount portion **26** and the cylinder **36** of the cartridge **35**.

Further, indicated at **52** is an ejection air passage which is provided on the housing **22** and opened in the bottom portion **26**A of the cartridge mount portion **26**. This ejection air passage **52** is connected to the ejection air source **9** through the air hose **9**A. By supplying air to the vacuum space **51**, the ejection air passage **52** releases the cartridge **35** from cartridge mount portion **26** by canceling the vacuum grip, thereby permitting to dismantle the paint cartridge **35** from the housing.

Denoted at **53** is a thinner valve receptacle portion which is provided in the head portion **24** of the housing **22**. As shown in FIG. **5**, this thinner valve receptacle portion **53** is in the form of a round bore which is located in a deep

position axially spaced from the female connector portion **26**B. Further, provided between the thinner valve receptacle portion **53** and the female connector portion **26**B is a thinner valve receiving bore **53**A which is extended to as far as a point which meets the thinner passage **48** on the side of the housing **22**. As described below, a thinner valve **54** is accommodated in the thinner valve receptacle portion **53**.

The thinner valve **54** is provided within the length of the thinner passage **48** on the side of the housing **22** to serve as an extruding fluid valve. This thinner valve **54** is opened to supply thinner to the thinner chamber **42** at the time of feeding paint in the paint reservoir chamber **41** to the rotary atomizing head **30**.

Similarly to the above-described paint valve **46**, the thinner valve **54** is constituted by a piston **54**A which is slidably received in the thinner valve receptacle portion **53**, a valve body **54**B which is connected to the piston **54**A at its base end and projected into the thinner passage **48** through the valve receiving bore **53**A to seat on and off a valve seat **48**A at its fore end, and a valve spring **54**C which constantly biases the valve body **54**B in the seating direction through the piston **54**A. Further, by the piston **54**A, the thinner valve receptacle portion **53** is divided into a spring chamber **54**D which accommodates the above-mentioned valve spring **54**C, and a pressure receiving chamber **54**E into which pilot air is introduced. Thus, the thinner valve **54** is constructed as an air pilot operated control valve.

Normally, under the influence of the biasing action of the valve spring **54**C, the valve body **54**B of the thinner valve **54** is seated on the valve seat **48**A of the thinner passage **48**, thereby shutting off the thinner passage **48** to stop thinner supply to the thinner chamber **42**. On the other hand, when pilot air is supplied to the pressure receiving chamber **54**E from the thinner valve pilot air source **11** through the air hose **11**A and pilot air passage **55**, the valve body **54**B is unseated from the valve seat **48**A against the action of the valve spring **54**C to permit thinner supply to the thinner chamber **42**. In this instance, one end of the pilot air passage **55** is connected to the thinner valve pilot air source **11** through the air hose **11**A, while the other end is communicated with the pressure chamber **54**E of the thinner valve **54**.

The opening and closing actions of the paint valve **46** and of the thinner valve **54** are controlled to take place synchronously with start and stop of a servo motor **63** which will be described hereinafter. Therefore, upon stopping a coating operation, paint is prevented from flowing out from the paint supply passage **39**A of the feed tube **39** and the paint reservoir chamber **41** by the residual thinner pressures in the thinner chamber **42** and in the thinner passage **43** on the side of the cartridge.

Denoted at **56** is a thinner feeding device which serves as an extruding liquid feeding means. As shown in FIG. **1**, this thinner feeding device **56** is mounted on the vertical arm **3** of the coating robot **1**. Further, as shown in FIGS. **8** to **10**, the thinner feeding device **56** is constructed as a positive displacement pump, including a bottomed cylinder **57** which has a bottom portion **57**A located on the front side, a piston **59** which is slidably received in the cylinder **57** in such a way as to define a thinner feeding chamber **58**, a piston rod **60** which is axially extended from the piston **59** and provided with a downwardly bent portion at its fore end, a female screw **61** which is formed at the fore end of the piston rod **60**, a male screw **62** which is extended parallel with the piston rod **60** and engaged with the female screw **61** through a large number of steel balls (not shown), forming a ball screw together with the female screw **61**, and a servo motor **63** which is connected to the male screw **62**. In this instance, the servo motor **63** is controlled to start and stop in synchronism with opening and closing actions of the paint valve **46** and of the thinner valve **54**.

Further, provided in the bottom portion **57**A of the cylinder **57** are a thinner supply passage **64** which is connected to the thinner passage **48** on the side of the housing through a thinner hose (not shown), a thinner replenishing passage **65** which is connected to the thinner reservoir or thinner source **12** through the thinner hose **12**A to serve as an extruding liquid replenishing conduit, and a drain passage or conduit **66** which is connected to the drain side. These thinner supply passage **64**, thinner replenishing passage **65** and drain passage **66** are respectively communicated with the thinner feeding chamber **58**.

Indicated at **67** is a thinner supply valve which is provided in the thinner supply passage **64** in the bottom portion **57**A of the cylinder to serve as an extruding liquid supply valve. This thinner supply valve **67** is normally closed to shut off the thinner supply passage **64**, and opened to put the thinner supply passage **64** in communication only when pilot air is supplied thereto.

Denoted at **68** is a thinner replenishing valve which is provided in the thinner replenishing passage **65** in the bottom portion **57**A of the cylinder **57** to serve as an extruding liquid replenishing valve. This thinner replenishing valve **68** is normally closed to shut off the thinner replenishing passage **65**, and opened to put the thinner replenishing passage **65** in communication only when pilot air is supplied thereto.

Indicated at **69** is a bubble extraction valve which is provided in the drain passage **66** in the bottom portion **57**A of the cylinder **57**. This bubble extraction valve **69** is normally closed to shut off the drain passage **66**, and opened to put the drain passage **66** in communication only when pilot air is supplied thereto.

With the thinner feeding device **56** which is arranged as described above, when the servo motor **63** is rotated in the forward direction to turn the male screw **62** relative to the female screw **61**, the piston **59** is displaced through the piston rod **60** at a constant speed in the direction of arrow A as shown in FIGS. **6** and **10**, thereby causing the thinner in the thinner feeding chamber **58** to flow out either into the thinner supply passage **64** or into the drain passage **66**. On the other hand, when the servo motor **63** is rotated in the reverse direction, the piston **59** is displaced in the direction of arrow B as shown particularly in FIG. **9** to suck in thinner through the thinner replenishing passage **65**.

In this instance, for the sake of air bubble extraction which will be described hereinafter, the fore end of the cylinder **57**, with the bubble extraction valve **69**, is located on the top side when mounting the thinner feeding device **56** on the vertical arm **3** of the coating robot **3**.

On the other hand, indicated at **70** (in FIG. **1**) is a cartridge holder table which is provided in a coating booth and in a position in the vicinity of the coating robot **1**. Placed on the cartridge holder table **70** are paint cartridges **35***a*, **35***b* . . . **35***n* of different colors. In addition to the paint cartridges, supported on the cartridge holder table **70** are a number of utility equipments (not shown), including a paint refilling device to be used at the time of refilling paint into the paint reservoir chamber **41** of the cartridge **35**, a thinner collecting device to be used for collecting thinner which is discharged from the thinner chamber **42** at the time of refilling paint, and a cartridge changer to be used at the time of replacing a cartridge **35** on the housing **22**. Besides, an atomizing head

washing device (not shown) is provided in the vicinity of the cartridge holder table **70** to wash off residues of previous color from the rotary atomizing head **30** when changing the paint color.

The rotary atomizing head type coating system **21** of the present embodiment, with the above-described arrangements, is operated in the manner as described below with reference to the time chart of FIG. **11**.

Firstly, upon finishing a coating operation in color a, for example, the paint color is changed from color a to color b in the following manner. In this case, a paint cartridge **35***a* of color a which is now mounted on the housing **22** is replaced by a paint cartridge **35***b* of color b.

At the time of changing the paint color from a to b, while the cartridge **35***a* of color a is on the cartridge mount portion **26** of the housing **22**, the paint valve **46** is closed to shut off the paint supply passage **39**A of the feed tube **39**, and the thinner valve **54** is also shut off to close the thinner passage **48** on the side of the housing. In the meantime, on the side of the thinner feeding device **56**, the servo motor **63** is stopped, and the thinner supply valve **67** is closed to shut off the thinner supply passage **64**. Moreover, power supply to the high voltage generator **32** from the power source **6** is stopped upon completing a coating operation in color a.

More particularly, the following operations are performed when changing the paint color. Firstly, while the paint cartridge **35***a* of color a is still on the housing **22**, the coating machine **28** is moved toward the atomizing head washing device in the vicinity of the cartridge holder table **70** by operating the vertical and horizontal arms **3** and **4** of the coating robot **1**.

As soon as the coating machine **28** (rotary atomizing head **30**) is located face to face with the atomizing head washing device, wash thinner is spurted against the rotary atomizing head **30** to wash off deposited residues of color a therefrom.

Subsequent to the atomizing head washing or cleaning operation, the paint cartridge is replaced in the manner as follows. For the replacement of the paint cartridge, the air motor **29** is turned off, and the supply of shaping air is stopped. At the same time, air from the vacuum generating source **8** is cut off to cancel the suction force which has been holding the cartridge **35***a* fixedly against the housing **22**. Thereafter, air from the ejection air source **9** is supplied to the vacuum space **51** through the air hose **9**A and ejection air supply passage **52** to free the paint cartridge **35***a* from the cartridge mount portion **26**, and the cartridge **35***a* is extracted axially out of the housing **22** and returned to the cartridge holder table **70**.

After unloading or dismantling the paint cartridge **35***a* of color a from the housing **22** in this manner, the paint cartridge **35***b* of color b is picked up from the cartridge holder table **70** and mounted on the housing **22**. At this time, while the cylinder **36** is being set in position on the cartridge mount portion **26** of the head portion **24**, the feed tube **39** is inserted into the feed tube passage hole **34** on the side of the coating machine through the conical recess **27**B of the feed tube passage hole **27** and the feed tube passage portion **27**A on the side of the housing **22**.

Further, as the cartridge **35***b* is mounted on the cartridge mount portion **26** of the housing **22**, the male and female connecting portions **36**A and **36**B of the cylinder **36** are coupled with the female and male connecting portions **26**B and **26**C on the cartridge mount portion **26**. Therefore, the position of the cylinder **36** in the circumferential direction relative to the cartridge mount portion **26** is determined by coupling engagement of these connecting portions. Besides, at this time, the conical projection **38** which is formed on the side of the cartridge **35***b* is brought into fitting engagement with the conical recess **27**B on the housing **22**, placing the feed tube **39** in a centered position relative to the feed tube passage hole **27** on the housing and the feed tube passage hole **34** on the coating machine and simultaneously determining its axial position relative to the cartridge mount portion **26**.

Further, when the cylinder **36** of the paint cartridge **35***b* is set in position on the cartridge mount portion **26**, the valve of the quick coupling **44** is opened to communicate the thinner passage **43** on the side of the cartridge with the thinner passage **48** on the side of the housing.

Then, after insertion of the cartridge **35***b* into the cartridge mount portion **26**, air in the vacuum space **51** between the cartridge mount portion **26** and the cylinder **36** is sucked out by the vacuum source **8** through the air suction passage **50**. Accordingly, the cartridge **35***b* of color b is securely gripped in position of the housing **22** by vacuum, and thereby preventing from coming off its position in the housing.

As soon as the cartridge **35***b* of color b is fixedly set in position on the housing **22** in this manner, air is supplied from the control air source **7** to drive the air motor **29**, putting the rotary atomizing head **30** in rotation and spurting out shaping air through the respective shaping air outlet holes **31**A in the shaping air ring **31** to standby for a coating operation.

In the meantime, a thinner replenishing operation for the thinner feeding device **56** is carried out simultaneously with the above-described replacement of the paint cartridge **35***a* and **35***b*.

In the thinner replenishing operation, firstly thinner is sucked into the thinner feeding chamber **58** to compensate for the thinner which had been used in spraying the previous color a. For this purpose, the thinner replenishing valve **68** is opened to connect the thinner feeding chamber **58** in the cylinder **57** with the thinner reservoir **12** through the thinner replenishing passage **65** and thinner hose **12**A, followed by reverse rotation of the servo motor **63**.

As a consequence, at the thinner feeding device **56**, the piston **59** is displaced in the direction of arrow B as shown in FIG. **9** to suck thinner into the thinner feeding chamber **58** from the thinner reservoir or source **12** through the thinner hose **12**A and thinner replenishing passage **65**.

When thinner is sucked and replenished into the thinner chamber **58** from the thinner reservoir **12** in this way, a slight amount of air is trapped in the form of air bubbles in the thinner flow to the thinner feeding chamber **58**. The air bubbles which are contained in thinner are compressed when the thinner is pumped out at the time of a coating operation, and could destabilize the thinner feed rate.

To avoid this, air bubbles in thinner are removed as soon as a predetermined amount of thinner is filled in the thinner feeding chamber **58**. More specifically, as shown in FIG. **10**, the thinner replenishing valve **68** is closed to shut off the thinner replenishing passage **65**, and then the air bubble extraction valve **69** is opened to communicate the thinner feeding chamber **58** with the drain side through the drain passage **66**. Then, the servo motor **63** is rotated in the forward direction in this state.

At this time, since the cylinder **57** of the thinner feeding device **56** is mounted on the vertical arm **3** of the coating robot **1** with the air bubble extraction valve **69** on the upper side, air bubbles in the thinner feeding chamber **58** tend to gather within or in the vicinity of the drain passage **66**. Therefore, air bubbles can be expelled to the drain side

through the drain passage **66** simply by displacing the piston **59** over a small distance in the direction of arrow A by means of the servo motor **63**. After removal of air bubbles from thinner, the bubble extraction valve **69** is closed to end the thinner replenishing operation.

Following the above-described cartridge replacement from color a to color b and thinner replenishment to the thinner feeding device **56**, the machine is put in an operative state again for a coating operation in color b in the manner as follows.

Firstly, in the case of a coating operation in color b, the paint valve **46** and the thinner valve **54** are opened to put into communication the paint supply passage **39**A of the feed tube **39** as well as the thinner passage **48** on the side of the housing. Then, power is supplied from the power source **6** to the high voltage generator **32** through the power line **6**A to apply a high voltage to the air motor **29** and rotary atomizing head **30**.

In the meantime, at the thinner feeding device **56**, the thinner supply valve **67** is opened as shown in FIG. **8** to communicate the thinner feeding chamber **58** with the thinner reservoir chamber **42** of the paint cartridge **35***b* through the thinner supply passage **64**, the thinner passage **48** on the side of the housing and the thinner passage **43** on the side of the cartridge. Then, the servo motor **63** is rotated in the forward direction, thereby displacing the piston **59** at a constant speed in the direction of arrow A to supply thinner in the thinner feeding chamber **58** quantitatively to the thinner reservoir chamber **42** of the paint cartridge **35***b* through the thinner passages **48** and **43**.

Consequently, the piston **40** of the cartridge **35***b* is displaced at a constant speed toward the feed tube **39** by the thinner which is introduced into the thinner reservoir chamber **42**, thereby causing the paint of color b in the paint reservoir chamber **41** to flow out toward the rotary atomizing head **30** through the paint supply passage **39**A of the feed tube **39**.

Then, the paint of color b which is supplied forward through the paint supply passage **39**A of the feed tube **39** gets onto the rotary atomizing head **30** which is put in high speed rotation by the air motor **29**, and applied with a high voltage on the rotary atomizing head **30**. Therefore, the paint of color b is centrifugally atomized into fine particles by the rotary atomizing head **30**, and sprayed in the form charged and finely divided particles. On the other hand, by the action of the shaping air which is spurted out through the respective shaping air outlet holes **31**A of the shaping air ring **31**, the charged paint particles are shaped into a desired spray pattern, and said particles fly toward a coating object along an electrostatic field which is formed between the coating machine and the coating object to deposit on.

During a coating operation, the coating machine **21** is put in reciprocating movements along surfaces of a coating object. In order to prevent the coating from getting thicker locally at reversing positions of the coating machine **21**, it is the general practice to reverse the movement of the coating machine **21** at positions outside a coating surface of work and to stop paint spraying at these reversing positions. Accordingly, the paint spraying by the coating machine **21** is turned on and off repeatedly for coating a single piece of work.

Therefore, in the course of a coating operation, the opening and closing motions of the paint valve **46** and of the thinner valve **54** are controlled in synchronism with actuation and de-actuation of the servo motor **63** as shown in FIG. **11**. More particularly, when the servo motor **63** is stopped to hold paint spraying temporarily, the paint valve **46** is closed to shut off the paint supply passage **39**A of the feed tube **39**, and at the same time the thinner valve **54** is closed to shut off the thinner passage **48** on the side of the housing.

Accordingly, when paint spraying is stopped, no pressure acts on the thinner in the thinner passage **43** and thinner reservoir chamber **42** on the side of the cartridge to suspend the outflow of paint from the paint supply passage **39**A of the feed tube **39**. This makes it possible to turn on and off the paint supply to the rotary atomizing head **30**, namely, to turn on and off the paint spraying operation definitely in a reliable manner.

Thus, according to the present embodiment of the invention, the paint supply from the feed tube **39** to the rotary atomizing head **30** turned on and off by the paint valve **46** which is provided on the cartridge **35** to open and close the paint supply passage **39**A of the feed tube **39**, while the thinner supply to the thinner chamber **42** is turned on and off by the thinner valve **54** which is provided on the housing **22** to open and close the thinner passage **48** on the side of the housing. Therefore, in response to a command signal to start or to stop spraying, the paint spraying operation can be started or stopped immediately since the paint valve **46** and the thinner valve **54** are opened or closed on such a command signal.

Consequently, the above-described arrangements make it possible to form coatings of improved quality, which are uniform in thickness, and to improve the reliability of the coating machine **21**. Besides, it becomes possible to prevent paint drips from the feed tube **39** when the cartridge **35** is extracted from the housing **22** for replacement.

In addition, the use of replaceable paint cartridges **35**, which are each filled with a paint, permits to omit paint hoses which are otherwise required to supply paint from a paint storage or source and to preclude leaks of high voltage through paint, obviating the necessity for using an insulation structure (a voltage block structure) for the paint storage or source.

In feeding paint from the paint reservoir chamber **41** to the rotary atomizing head **30**, the piston **40** is displaced by thinner which is a non-compressive fluid. Therefore, the piston **40** can be displaced accurately at a constant speed to form coatings which are improved in quality, improved especially in uniformity in thickness, without adding a flowmeter and control valves for this purpose. This will lead to enhanced reliability and reductions in cost.

Further, the thinner feeding device **56** is arranged as a positive displacement pump means or a piston type pump, feeding thinner quantitatively to the thinner chamber **42** by the piston **59** which is displaced by the servo motor **63**. Accordingly, the thinner feeding device **56** can feed paint to the rotary atomizing head **30** stably from the paint reservoir chamber **41**, delivering paint through the feed tube **39** at a constant rate to form coatings of improved quality.

Furthermore, the paint valve **46** and thinner valve **54** are arranged as an air pilot operated control valve in the present embodiment. Therefore, both of paint valve **46** and thinner valve **54** are simple in construction to make piping work simple as well, ensuring improved working efficiency in addition to reductions in cost.

Further, since the opening and closing motions of the paint valve **46** and thinner valve **54** are synchronized with starting and stopping motions of the servo motor **63** of the thinner feeding device **56**, it becomes possible to control the paint valve **46** and thinner valve **54** more precisely in relation with on- and off-timings of the paint spraying operation for improving the quality of coatings all the more.

Further, the cylinder **36** can be oriented into a predetermined position relative to the cartridge mount portion **26** in the circumferential direction by coupling engagement of the female and male connecting portions **26**B and **26**C, which are provided on the cartridge mount portion **26**, with the male and female connecting portions **36**A and **36**B on the side of the cylinder **36**.

Further, similarly by coupling engagement of the conical projection **38** on the cartridge **35** with the conical recess **27**B which is provided at a deep position on the cartridge mount portion **26**, the paint cartridge **35** can be oriented into a predetermined position relative to the cartridge mount portion **26** of the housing **22** in the axial and radial directions, helping to enhance the efficiency of assembling work and to shorten the time required for the color changing work.

Moreover, through the air suction passage **50** which is opened at the bottom of the cartridge mount portion **26**, air is sucked out of the vacuum space **51** between the cartridge mount portion **26** and the cylinder **36** to hold the paint cartridge **35** fixedly in position on the housing **22** with suction force, thereby preventing the paint cartridge **35** from getting loose. Besides, upon supplying air to the vacuum space **51** through the ejection air supply passage **52**, the paint cartridge **35** is released from the cartridge mount portion **26** as a result of cancellation of the vacuum grip and therefore can be unloaded or dismantled from the housing **22**.

On the other hand, the quick coupling **44**, which is provided at the open end of the thinner passage **43** on the side of the paint cartridge, is opened when the cartridge **35** is loaded on the cartridge mount portion **26** and closed as soon as the cartridge **35** is unloaded therefrom, thereby preventing thinner from dripping while loading or unloading the cartridge **35** on or from the cartridge mount portion **26**, improving the efficiency and environmental conditions of the loading and unloading work.

Further, since the air passages **33** for the turbine air, bearing air, brake air and shaping air are formed within the neck portion **23** of the housing **22**, utilizing the internal space of the housing **22** for these air passages **33** instead of using air hoses or the like, the assembling work can be simplified by omitting connections of air hoses and the system can be built into an uncomplicated form in outer appearance.

Further, since the high voltage generator **32** is built into the neck portion **23** of the housing **22**, utilizing the internal space of the housing **22**, the system as a whole can be arranged in a compact form.

Furthermore, since the piston **40** is slidably fitted into the cylinder **36** of the paint cartridge **35** as a movable partition wall and arranged to be pushed by thinner which is supplied thereto through the thinner passage **43** on the side of the cartridge, the cartridge **35** can be simplified in construction to make the assembling work easier and to permit reductions in cost.

Referring now to FIG. **12**, there is shown a second embodiment of the present invention which is characterized in that the thinner valve is provided on the side of the paint cartridge as a paint-extruding liquid valve. In the following description, those component parts which are common with the foregoing first embodiment are simply designated by common reference numerals or characters to avoid repetitions of same explanations.

Denoted at **81** is a rotary atomizing head type coating system according to this embodiment, and at **82** is a housing of the coating system **81**. Substantially in the same manner as the housing **22** in the foregoing first embodiment, the housing **82** of this embodiment is constituted by a neck portion **83** and a head portion **84**. The head portion **84** is formed with a coating machine mount portion **85**, a cartridge mount portion **86**, and a feed tube passage hole **87** on the side of the housing. In the case of the housing **82** according to the present embodiment, however, the thinner valve receptacle portion **53** as in the housing **22** of the first embodiment is abolished in this case.

Indicated at **88** is a paint cartridge which is employed in this embodiment. Similarly to the paint cartridges **35** of the first embodiment, a plural number of cartridges **88** are provided for different paint colors a, b, . . . and n. Each paint cartridge **88** is largely constituted by a cylinder **89**, a conical projection **90**, a feed tube **91**, a piston **92**, a thinner passage **93** on the side of the cartridge, and a paint valve receptacle portion **94** which accommodated a paint valve **95**. The cartridge **88** of this embodiment, however, differs from the cartridge **35** of the first embodiment in that a thinner valve receptacle portion **96** is located within the length of the thinner passage **93** on the side of the cartridge and in a position in a fore end portion of the cylinder **89**.

Indicated at **97** is a thinner valve which is provided in the thinner valve receptacle portion **96** to serve as an extruding liquid valve. Similarly to the thinner valve **54** in the first embodiment, the thinner valve **97** is biased to normally shut off the thinner passage **93** on the side of the cartridge, and to put the thinner passage **93** into communication only when pilot air supplied.

The quick coupling **98** which is provided at the open end of the thinner passage **48** on the side of the housing is arranged in the same way as the quick coupling **44** in the first embodiment.

The present embodiment, with the arrangements just described, can produce substantially the same operational effects as the foregoing first embodiment.

Referring now to FIG. **13**, there is shown a third embodiment of the present invention, which is characterized in that an extruding liquid feeding means is constituted by a gear pump and a servo motor which rotationally drives the gear pump. In the following description, those component parts which are common with the above-described first embodiment are simply designated by common reference numerals or characters to avoid repetition of same explanations. Besides, various component parts are indicated only by reference numerals or diagrammatic symbols for the sake of simplicity of illustration.

Indicated at **101** is a rotary atomizing head type coating system according to the present embodiment, and at **102** is a thinner feeding device which is provided on the coating system **101** as an extruding liquid feeding means. The thinner feeding device **102** is arranged as a positive displacement pump, including a gear pump **103** and a servo motor **104** which rotationally drives the gear pump **103** to feed thinner quantitatively to the cartridge **35**.

In this instance, similarly to the servo motor **63** in the above-described first embodiment, the servo motor **104** is controlled to start and stop in synchronism with opening and closing motions of the paint valve **46** and the thinner valve **54**.

Thus, by the gear pump **103** which is driven at a constant rotational speed by the servo motor **104**, thinner is quantitatively supplied from the thinner feeding device **102** to the cartridge **35**.

The present embodiment, with the arrangements just described, can also produce almost the same operational

effects as each one of the foregoing embodiments. Especially in the case of this embodiment employing commercially available gear pump **103** for the thinner feeding device **102**, it becomes possible to simplify its construction and to realize reductions in cost. The gear pump **103** can be started and stopped in synchronism with opening and closing motions of the paint valve **46** and thinner valve **54** to turn on and off paint spraying in accurate timings.

FIG. **14** illustrates a modification of the paint cartridge according to the present invention, which can be employed in place of the above-described paint cartridge **35**. In this case, the paint cartridge is provided with a movable partition wall in the form of a bellows tube.

More particularly, indicated at **111** is the paint cartridge of a modified construction. Similarly to the paint cartridge **35** in the first embodiment, the paint cartridge **111** is largely constituted by a cartridge cylinder **112**, a conical projection **113** which is provided at the fore end of the cylinder **112**, a feed tube **114** which is extended axially from and on the front side of the conical projection **113**, a thinner passage or conduit **115** on the side of the cartridge, and a paint valve receptacle portion **116** which accommodates a paint valve **117**.

This modification, however, differs from the cartridge **35** of the first embodiment in that the cylinder **112** of the cartridge **111** is internally provided with bellows to serve as a movable partition wall as described hereafter.

Indicated at **118** is a bellows tube which is provided internally of the cylinder **112** as a movable partition wall. The bellows tube **118** is foldably stretchable in the axial direction and internally defines a paint reservoir chamber **119** in communication with a paint supply passage **114**A of the feed tube **114**. Defined between the bellows tube **118** and the cylinder **112** is a thinner chamber **120** which functions as an extruding liquid chamber.

The paint cartridge **111**, with the arrangements just described, can produce substantially the same operational effects as the counterpart in the foregoing embodiments. Especially in the case of the cartridge **111** employing the bellows tube **118** as a movable partition wall, the paint and thinner can be definitely separated from each other, completely precluding the possibilities of the thinner in the cylinder creeping into the paint to degrade the quality of coatings.

In the foregoing embodiments, the coating system **21**, **81** or **101** is shown as being mounted on the horizontal arm **4** of the coating robot **1**. However, the present invention is not limited to this particular form shown. For example, if desired, the coating system **21**, **81** or **101** may be mounted on a reciprocator or the like. Further, although a movable partition wall is constituted by the piston **40** in the first to third embodiments and by the bellows tube **118** in the above-described modification, it may be realized in other forms, for example, may be in the form of an inflatable bag of resilient material having an internal space thereof communicated with the feed tube.

Further, in the foregoing embodiments, the axial bore **29**B of the air motor **29** is shown as being formed in a stepped form including a rear small-diameter portion and a front large-diameter portion, and the rotational shaft **29**C is received in the large-diameter portion of the axial bore **29**B. However, it is to be understood that the present invention is not limited to this particular example. For example, as shown in the modification of FIG. **15**, an air motor **131** may be constituted by a motor case **131**A with an axial bore **131**B, which has almost a uniform diameter in the axial direction, and a rotational shaft **131**C which is extended through the entire length of the axial bore **131**B. In this instance, a feed tube passage hole **132** on the side of the coating machine is provided internally of the rotational shaft **131**C in coaxial relation with the feed tube passage hole **27** on the side of the housing.

Further, although thinner is used as an extruding liquid by way of example in the foregoing embodiments, water or other extruding liquid may be applied depending upon the type of paint or high voltage application system to be used.

Furthermore, in the foregoing embodiments, two or more spare paint cartridges **35**, **88** or **111** may be provided for each color if desirable in consideration of the convenience or efficiency of the cartridge changing operation in a continuous coating operation in the same color.

As clear from the foregoing particular description, according to the present invention, a paint valve is provided on each paint cartridge to communicate or shut off a paint supply passage in a feed tube, thereby turning on and off paint supply to a rotary atomizing head from the feed tube, while an extruding liquid valve is provided within the length of an extruding liquid passage which is provided either on the side of a housing or on the side of the paint cartridge, thereby turning on and off extruding liquid supply to an extruding liquid chamber within the cartridge. Therefore, the paint spray is turned off as soon as the paint valve is closed to shut off the paint supply passage in the feed tube, thereby cutting off the paint supply to the rotary atomizing head. Besides, the supply of the extruding liquid to the extruding liquid chamber is cut off as soon as the extruding liquid valve is closed to shut off the extruding liquid passage either on the side of the housing or on the side of the paint cartridge. At the time of stopping paint spraying, the supply of paint as well as the supply of the extruding liquid can be immediately cut off by way of the paint valve and the extruding liquid valve, respectively.

As a consequence, it becomes possible to turn on and off the paint supply to the rotary atomizing head definitely in a secure manner, and to form coatings of improved quality, which are uniform in thickness, thereby reflecting higher reliability of the coating system. In addition, paint drips from the feed tube, which might lead to coating defects, can be prevented at the time of extracting the paint cartridge from the housing for replacement. Further, it also becomes possible to prevent leaks of high voltage through paint thanks to the omission of a paint hose which would be normally required for connection to a paint reservoir or source. Furthermore, with regard to the movable partition wall in the paint cartridge, which is displaced by an extruding liquid, the piston can be displaced accurately at a constant speed by the use of a non-compressive liquid.

What is claimed is:

1. A rotary atomizing head type coating system, including:

a housing having a coating machine mount portion on the front side and a cartridge mount portion on the rear side thereof;

a coating machine adapted to be mounted on said coating machine mount portion of said housing, and having an air motor with a rotational shaft and a rotary atomizing head mounted on a front end portion of said air motor;

a feed tube passage hole provided internally of and axially through said rotational shaft of said air motor, and having a front end opened into said rotary atomizing head and a rear end opened into said cartridge mount portion of said housing; and

a plural number of paint cartridges containing paint of different colors in respective cartridge cylinders, each

one of said paint cartridges being adapted to be replaceably and selectively loaded on said cartridge mount portion of said housing and having a feed tube extended axially forward from a front end portion of said cartridge cylinder for placement in said feed tube passage hole; characterized in that said coating system comprises:

on the side of said cartridge, a movable partition wall dividing said cylinder into a paint reservoir chamber in communication with said feed tube and an extruding liquid chamber, an extruding liquid passage for supplying an extruding liquid to said extruding liquid chamber, and a paint valve to turn on and off paint supply from said feed tube to said rotary atomizing head;

on the side of said housing, an extruding liquid passage in communication with said extruding liquid passage on the side of said cartridge; and

an extruding liquid valve provided within the length of said extruding liquid passage either on the side of said cartridge or on the side of said housing to turn on and off extruding liquid supply to said extruding liquid chamber.

2. A rotary atomizing head type coating system as defined in claim **1**, further comprising an extruding liquid feeding means connected to said extruding liquid passage on the side of said housing and adapted to supply an extruding liquid quantitatively to said cartridge.

3. A rotary atomizing head type coating system as defined in claim **2**, further comprising a coating robot with vertical and horizontal arms, said housing of said coating system being mounted on a fore end portion of said horizontal arm of said coating robot, and said extruding liquid feeding means being mounted on said vertical arm.

4. A rotary atomizing head type coating system as defined in claim **2**, wherein said extruding liquid feeding means is in the form of a positive displacement pump means constituted by a piston type pump having a cylinder and a piston, and a servo motor for displacing said piston of said piston type pump.

5. A rotary atomizing head type coating system as defined in claim **4**, wherein said extruding liquid feeding means comprises, in a fore end portion of said cylinder of said piston type pump and in communication with each other, an extruding liquid supply conduit connected to said extruding liquid passage on the side of said housing, an extruding liquid replenishing conduit connected to an extruding liquid source, and a drain conduit connected to a drain side, said extruding liquid supply conduit being provided with an extruding liquid supply valve to be opened only when said extruding liquid in said cylinder is supplied to said paint cartridge, said extruding liquid replenishing conduit being provided with a liquid replenishing valve to be opened only when said extruding liquid is replenished to said cylinder, and said drain conduit being provided with an air bubble extraction valve to be opened when removing air bubbles from an extruding liquid replenished to said cylinder.

6. A rotary atomizing head type coating system as defined in claim **4**, wherein said paint valve and said extruding liquid valve are adapted to open and close in synchronism with start and stop of said servo motor.

7. A rotary atomizing head type coating system as defined in claim **2**, wherein said extruding liquid feeding means is in the form of a positive displacement pump means constituted by a gear pump and a servo motor for rotationally driving said gear pump.

8. A rotary atomizing head type coating system as defined in claim **7**, wherein said paint valve and said extruding liquid valve are adapted to open and close in synchronism with start and stop of said servo motor.

9. A rotary atomizing head type coating system as defined in claim **1**, wherein said paint valve is in the form of an air pilot operated control valve normally biased in a closing direction by a valve spring and adapted to open upon applying pilot air thereto from outside to open a paint flow through said feed tube.

10. A rotary atomizing head type coating system as defined in claim **1**, wherein said extruding liquid valve is in the form of an air pilot operated control valve normally biased in a closing direction by a valve spring and opened upon application of pilot air thereto from outside to open an extruding liquid flow in said extruding liquid passage.

11. A rotary atomizing head type coating system as defined in claim **1**, wherein said cartridge mount portion of said housing is provided with a positioning coupler portion for engagement with a complementarily shaped positioning coupler portion on a front end portion of said cylinder of said paint cartridge.

12. A rotary atomizing head type coating system as defined in claim **1**, wherein said cartridge mount portion of said housing further comprises a vacuum space to be defined thereon in association with said cylinder of said cartridge when said cylinder is mounted in position on said cartridge mount portion, and an air suction passage opened to said vacuum space to suck air out of said vacuum space, holding said cartridge fixedly against said cartridge mount portion of said housing with suction force.

13. A rotary atomizing head type coating system as defined in claim **1**, wherein another feed tube passage hole is provided on said housing in coaxial relation with said feed tube in said rotational shaft.

14. A rotary atomizing head type coating system as defined in claim **1**, wherein said extruding liquid valve is provided in said extruding liquid passage on the side of said housing, and said extruding liquid passage on the side of said cartridge is provided with a valved quick coupling in an open terminal end portion thereof, said quick coupling being opened only when said paint cartridge is fully and fixedly coupled with said cartridge mount portion of said housing.

15. A rotary atomizing head type coating system as defined in claim **1**, wherein said extruding liquid valve is provided in said extruding liquid passage on the side of said housing provided with a valved quick coupling in an open terminal end portion thereof, said valved quick coupling being opened only when said paint cartridge is fully and fixedly coupled with said cartridge mount portion of said housing.

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